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SPECIFICITY OF MANTID OOTHECAE[1]

(Orthoptera: Mantidae)

OSMOND P. BRELAND,[2]
The University of Texas

JACK W. DOBSON,[2]
Mississippi State College

It has been known for some time that features other than the morphological characteristics of adult organisms are of importance in distinguishing between species, and in determining group relationships. Criteria that have been thus used include the structure of eggs and immature stages, physiological reactions such as the host specificity of parasites, and various physiological products such as the galls of some insects.

The senior writer's attention was first attracted to the possible significance of mantid oothecae or egg cases several years ago when he was investigating the biology of mantid egg parasites (Breland, 1941a). During the course of this study, it became evident that the type of egg mass produced by the different species of mantids varied considerably. An abstract of some observations in this connection was published (Breland, 1941b) and since that time, additional correlations have been made. Although photographs of the oothecae of several species of mantids have been published (Rau and Rau, 1913; Jones, 1933; Roberts, 1937a) so far as could be determined, there has never been a serious attempt to use these physiological products in taxonomic studies.

The following native species are dealt with in this paper: *Stagmomantis carolina* (Joh.), *S. californica* Rehn and Hebard, the Limbata complex (two species), *Brunneria borealis* Scudd., *Litaneutria minor* (Scudd.), and *Phyllovates chlorophaea* (Blanchard). It will be noted that two species are designated as the Limbata complex. The adults of these mantids are apparently not separable from each other in

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small series, and at the present time, both groups are considered to be *Stagmomantis limbata* (Hahn). The writers will shortly present evidence to support the contention that two species are involved. The type locality of *S. limbata* was simply stated to be "Mexico," and both species being considered in this paper probably occur in that country, since egg masses of both have been collected along the Texas border. It is thus not believed that at the present state of our knowledge the specific name *Stagmomantis limbata* (Hahn) should be applied to either species to the exclusion of the other.

Three introduced mantids, well established in the northeastern part of the United States, are also briefly considered for purposes of comparison. These include *Tenodera angustipennis* Sauss., *Tenodera aridifolia sinensis* Sauss., and *Mantis religiosa* L.

METHODS

During the course of this study which has extended over a period of several years, the writers have collected and examined hundreds of mantid egg cases. These collections have extended over most of Texas, and in some instances into adjoining states. In addition, collections of oothecae have been received from several individuals in other regions. Nine species of mantids have been stated to occur in Texas (Hebard, 1943), the native species listed above, and *Oligonicella mexicana* (Saussure & Zehntner), *Oligonicella scudderi* (Saussure), and *Yersiniops solitarium* (Scudder). The writers have not collected any egg cases of these three latter species, but have large series of the oothecae of the other mantids known to occur in the state.

Two methods were employed in determining the type of egg case produced by each species of mantid. One procedure was to collect adult females and keep them in the laboratory until they deposited egg masses. The oothecae thus produced were in most instances comparable to those deposited in nature. The principal differences in cases that were deposited in the laboratory as opposed to those produced in nature were in size and color. Oothecae that were deposited within a few days after the mantids were brought into the laboratory were usually of average size, but if the insects produced several cases, those deposited after a few weeks of laboratory residence were frequently smaller than the egg masses collected in the field. Laboratory produced oothecae were sometimes lighter in color than those deposited outdoors and exposed to climatic conditions.

In the laboratory the adult mantids were confined in bell jars 8 to 10 inches high and 8 inches in diameter. Several sheets of toweling paper were placed between the jars and the table upon which the jars rested. Within each jar was placed a small twig one-fourth to one-half inch in diameter, one end of which rested on the table while the other end leaned against the side of the jar. These slanting twigs furnished a place for the insects to rest, and they were usually used as a substratum for egg case deposition. A few drops of water were added each day to the toweling paper, and at least one living insect per day was introduced into each bell jar. Additional details of methods used in keeping living mantids in the laboratory may be found in a former paper (Breland, 1941c).

The females of *Stagmomantis carolina* seemed to react considerably better to laboratory conditions than did the females of other species, but the writers may have received the wrong impression since many more specimens of this species were used. As has been stated previously (Breland, 1941c), a large number of females of *S. carolina* have been kept for months in the laboratory, during which time most of the insects deposited several egg masses. Other mantids would frequently survive for several weeks, but aside from *L. minor*, these insects seldom produced more than a single normal case. Several females of *L. minor* have deposited two or three normal oothecae.

It was not possible to obtain living females of all species of mantids that were studied, and for these species, egg cases were collected, allowed to hatch in the laboratory and some of the young mantids were reared to maturity. A majority of the egg masses apparently hatched sooner under laboratory conditions than they would have normally, and in some instances, nymphal emergence was probably hastened by as much as two or three months.

As might have been expected, the nymphs of most species were intensely cannibalistic, and for this reason they were placed in individual containers. These containers consisted of small salad dressing jars of various sizes which were covered with tin tops through which holes had been punched. Toweling paper or a small twig was placed within each jar, since it was found that some type of substratum was essential to successful ecdysis. As a rule, the old skin remains attached to a substratum while the insect emerges therefrom, and without something that can be successfully grasped, the young mantid almost invariably dies during the process.

Drops of water were added daily to these individual containers, and the small mantids were fed on fruit flies kindly supplied by the geneticists of the Department of Zoology. As the mantids grew, they were transferred to larger containers and fed larger insects, and during the next to last instar, each specimen was placed in a bell jar of the type previously described.

THE OOTHECAE

The egg masses of the same species will, of course, vary somewhat in color, size and shape, but of the egg masses examined there has seldom been any doubt as to the species to which the case should be assigned. Of the hundreds that have been collected, less than a dozen have been so abnormal that uncertainty existed as to the species of mantid which produced them.

The actions of *Stagmomantis carolina* in depositing the oothecae, and the general structure of the egg masses have been previously described (Rau and Rau, 1913; Breland, 1941c). The methods of other species of mantids that the writers have observed producing egg masses conform in general to those of *S. carolina*.

Despite differences among the various oothecae that have been studied, they are all similar in fundamental structure. A brief consideration of the general structure of egg cases will be of assistance to the reader in understanding the terminology that is used for the various parts (Plate I).

The side attached to the substratum is designated as the ventral or basal surface, while the opposite side is the top or dorsal surface. The two ends of the cases are usually somewhat different in size and shape. In some, one end is slightly larger than the other, and the surface of this large end is frequently more vertical than is the surface of the other end. Since the mantid starts the case at the large end, this region is called the anterior end, while the opposite end is posterior (figure 1, Plate I). At the anterior end of the egg masses of some species, there is a small band of material extending ventrally that partially or completely surrounds the small twigs or weeds to which the oothecae are attached. This encircling band is broken if the case is pulled from the substratum.

In most species, there is a rather large emergence area on the dorsal surface, from which the young mantids emerge in the spring (E, Plate I, figure 1). The appearance of this region varies considerably, depending upon the species, and upon the time of year that the oothecae are collected. When the egg cases are first deposited, the emergence area is frequently partially filled with a whitish deposit which for a time covers the newly formed cases. This material gradually disappears as the oothecae are exposed to the weather, so that within a few months a series of partial or complete transverse slits may be seen in the emergence areas. These slits are separated by partitions of various lengths, depending upon the species of mantid. The ventral part of the emergence area is in connection with the dorsal ends of the eggs inside the case so that the young mantids issue from this region upon hatching. This connection between the emergence area and the ends of the eggs can best be seen in cross or sagittal section (Plate I, figures 3 and 4). The oothecae of all species studied, with the exception of those of *Brunneria borealis*, exhibit an obvious emergence area. The absence of this region in this species, as explained below, is one of the most interesting modifications discovered during this study.

In order for one to appreciate fully the complex structure of an ootheca, it is necessary to make sections of the cases in several planes and at a number of levels. The eggs within the case stand on end, and occur in rows. Each egg is enclosed within a cell, the walls of which have a tendency to form a hexagon, and this shape may be observed in a frontal section of the case which forms a transverse section of the individual egg cell. If a frontal section is made through an ootheca near the base (Plate I, fig. 2) it will be noted that the zig-zag partitions formed by the cell walls may be traced both lengthwise and transversely across the case.

The organization of the egg cells varies somewhat with the different species of mantid, but there are usually at least a few rows of cells that

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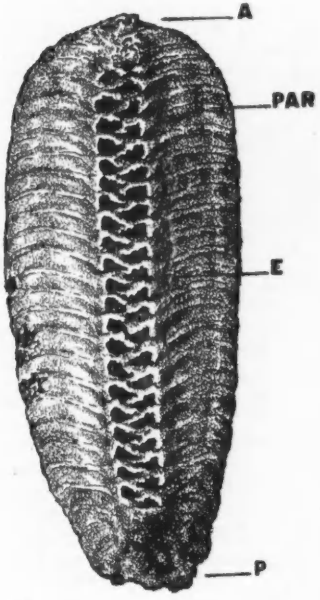
EXPLANATION OF PLATE I

Structure of mantid oothecae. FIG. 1. Dorsal view of complete case. FIG. 2. Frontal section near ventral surface. FIG. 3. Sagittal section. FIG. 4. Transverse section near center of case.

ABBREVIATIONS

A—anterior end.	E—emergence area.	Par.—partition.
C—egg cell.	P—posterior end.	S—air space.



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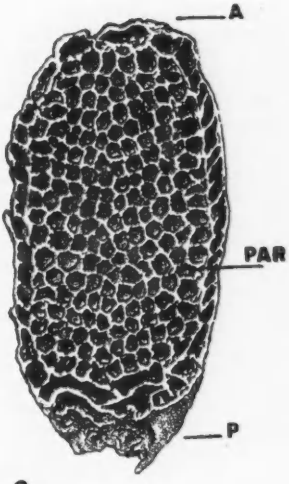

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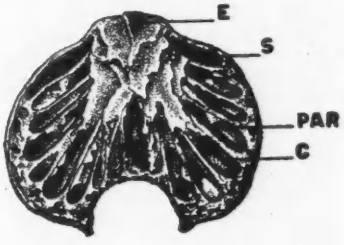

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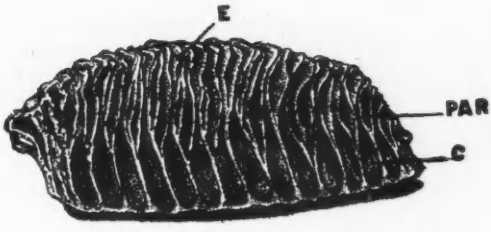


3

are perpendicular to the dorsal and ventral surfaces of the case. This alignment can best be seen in a cross or transverse section of the egg mass (Plate I, fig. 4). In this type of section it may also be noted that the dorsal ends of the egg cells are in contact with the ventral portion of the emergence area, and this fact may also be observed in a sagittal section (Plate I, fig. 3).

A varying amount of ootheca material completely encloses the mass of eggs. In some species, this material between the outer tiers of cells and the outside of the case may be quite thick, and in some instances, relatively large air spaces may occur in this area laterally and dorsally (S, Plate I, fig. 4). This type of air space usually extends almost the complete length of the oothecae. In some species the material surrounding the eggs possesses a large number of air spaces throughout its substance which causes the sides of the oothecae to be quite soft.

The substratum to which the egg masses are attached is apparently one of the most important factors that influence variations in the size and shape of many species. As a rule, an ootheca deposited upon a small twig is narrower, higher and longer than one attached to a broad surface such as a fence post or the side of a building.

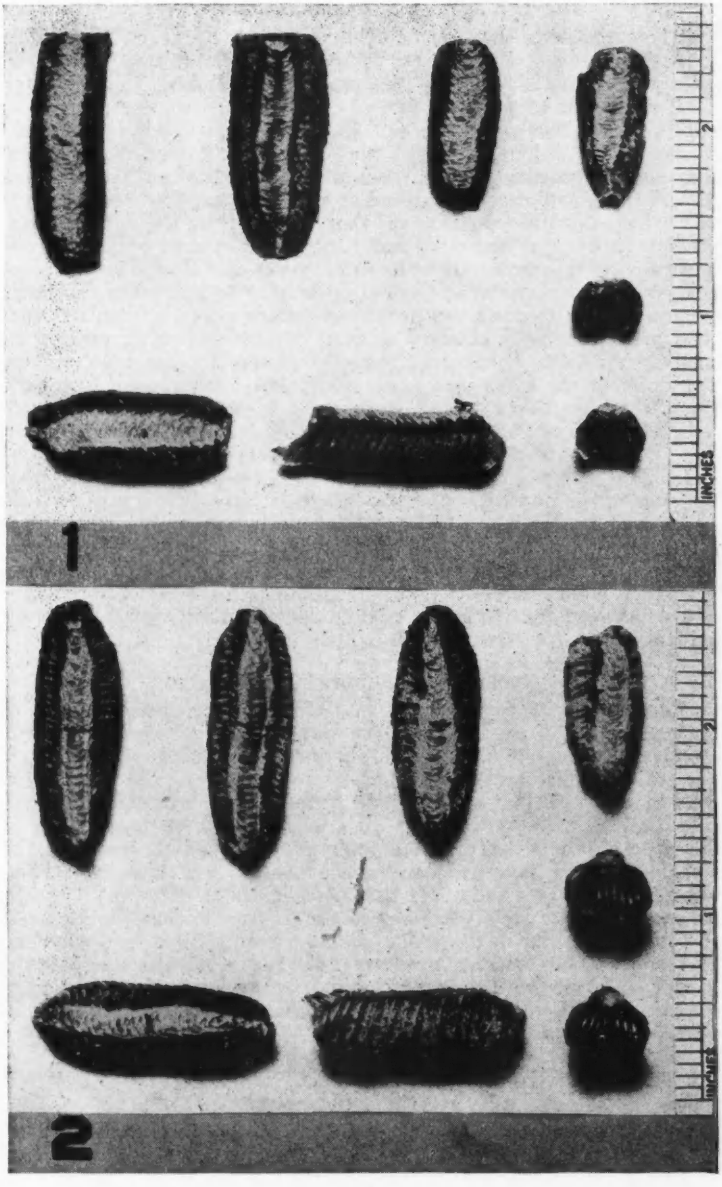
The egg masses of some species will vary somewhat in color depending upon their age. When oothecae are first produced, they are usually covered with a whitish deposition which gradually disappears in nature as the cases are exposed to the weather. If collections are made shortly after the masses are produced, the presence of this material causes many species to appear lighter in color than if they are collected a month or so later.

An even more striking color variation that is apparently dependent upon environmental factors, has been observed for some species. This variation and the possible influencing factors are discussed later in more detail.

Unless otherwise indicated in the legends of the photographs, all the oothecae of each species that are reproduced are from the same locality, and are of egg cases collected in nature. Although a series from the same locality does not always exhibit all the variations of size and shape that may be found for a particular species over its entire range, it is believed that such photographs will have a more permanent value. If some of the species which are at present recognized should, in the future, be divided into two or more species, the plates will still be of some use. Specific collection sites are given in all instances. All the photographs are of old cases from which the young mantids have emerged, or in which the eggs did not hatch and from which, in sections, the egg material has been removed. It is almost impossible to cut a section through an egg case containing viable eggs without breaking some of the egg membranes, thus allowing the liquid to flow over the exposed surface obscuring part of the fundamental structure.

EXPLANATION OF PLATE II

Mantid oothecae. FIG. 1. Oothecae of *Stagmomantis carolina* (Joh.). Collected 15 miles west of Canyon, Texas. FIG. 2. Oothecae of *Stagmomantis californica* Rehn & Hebard. Collected 45 miles west of Fort Stockton, Texas.


1
2

Stagmomantis carolina (Joh.)

The oothecae of this mantid (Plate II, fig. 1) are doubtless familiar to many biologists, since it is the commonest species in many areas, and since its known distribution covers much of the eastern United States.

Photographs of the egg cases of this species have been previously published by Rau and Rau (1913). As indicated before, the substratum upon which the masses are deposited influences the size and shape of the resulting case. The above writers state that most of their material was collected from fences, and the shape of the oothecae which they illustrate is typical of those collected by the writers of the present paper from flat surfaces. The broadest case of this species illustrated in this paper (Plate II, fig. 1) was also collected from a fence post, but all the others were found on twigs. Most of these oothecae thus differ somewhat in shape from those photographed by Rau and Rau.

The oothecae of *S. carolina* are more slender, and on an average are smaller than those of other species of *Stagmomantis* that were studied. The color of the cases varies somewhat depending upon the area in which they are deposited. They are frequently of a brownish grey color, but in some localities, they may be a light brown or orange color. The latter color is especially prevalent in western Texas, and as will be indicated later in the discussion of the oothecae of the Limbata complex, this color variation may be influenced by humidity.

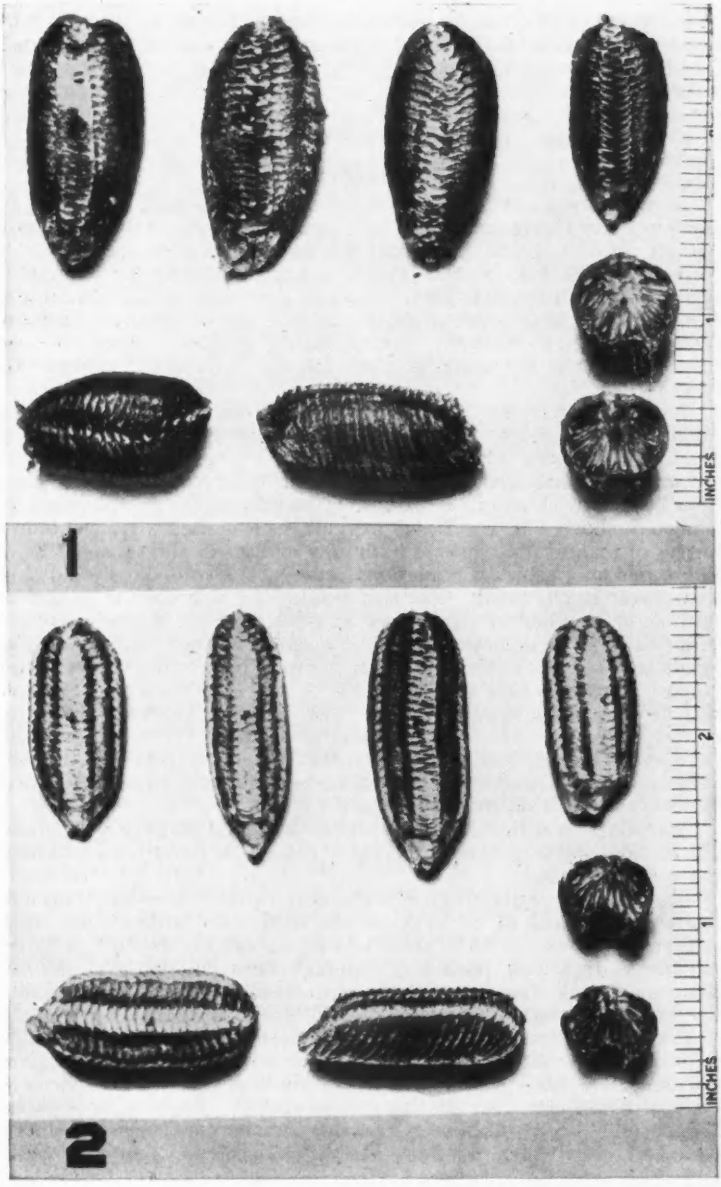
In cross section it will be noted that most of the egg cells are practically at right angles to the dorsal and ventral surfaces of the case. Most of the inside of the ootheca is occupied by the egg cells, the eggs, the partitions and other supporting material so that laterally the air spaces between the outer row of cells and the outside of the case are quite small.

Stagmomantis californica Rehn & Hebard

The oothecae of this species (Plate II, fig. 2) are similar to those of *S. carolina*. The egg cases of the two species are distinguishable, however, and those of *S. californica* that have been collected will average somewhat larger than the egg masses of *S. carolina*. The color of the ootheca of the former species varies from a light brownish yellow to almost white. The outstanding external feature of the egg masses of this species is a series of overlapping projections that occur on the dorsal side of the case in the emergence area. These flaps are inclined toward the posterior end of the case, and in freshly deposited oothecae the structures are tightly applied to the surface so that they are not obvious unless some of the white deposit covering the case is removed. The flaps become evident, however, if the finger nail is scraped across the top surface toward the posterior end, or if a longitudinal section of the case is made. In section it may be noted that these flaps are dorsal extensions of transverse partitions.

EXPLANATION OF PLATE III

Mantid oothecae, Limbata complex. FIG. 1. Species 1. Collected 14 miles south of Alpine, Texas. FIG. 2. Species 2. Collected 30 miles south of Falfurrias, Texas.


1
INCHES
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A cross section of the case of this species greatly resembles that of *S. carolina*. The cells are essentially perpendicular to the top and bottom of the ootheca, although there is in some instances a tendency for the outer rows to depart slightly from the vertical. The outer layer is thin, and the air spaces in this region are small. The oothecae are not quite as compact as are those of *S. carolina* and the sides may be slightly indented with a little pressure.

The **Limbata** Complex

It was previously indicated that the writers have considerable evidence that the mantids in Texas now recognized as *Stagmomantis limbata* (Hahn) should be considered as two distinct species. The oothecae of the two groups (Plate III) while similar are separable. Females of both mantids have deposited egg cases in the laboratory, and the differences between these oothecae are as great as between those collected in nature. Environmental influence upon the egg cases could thus not alone account for the differences between the two types.

Nymphal emergence from both types of egg cases have been observed from many localities. The first instar nymphs of one species are invariably green in color, while those of the other group are always brown. Nymphal emergence from a few laboratory deposited egg cases has occurred, and in all instances, the color of the nymphs were as indicated above. It has been previously recognized that the same species of mantid may include both grey and green adults, and that a long series may show all gradations between the two colors (Rau and Rau, 1913; Rehn, 1935). For this reason, the color of the adults of mantids is of doubtful significance in distinguishing between species. So far as could be determined, very little work has been done upon the significance of color of the first instar nymphs, but certain observations support the conclusion that the color of this stage is more constant than in the adults (Rau and Rau, 1913; Roberts, 1937a). Since the writers have never found an exception to the color difference between the nymphs hatched from the two types of egg cases, they feel that this difference, as explained above, should be regarded as additional evidence that the two mantids are not the same.

According to oothecae records, these two mantids have a different distribution, and as yet the two types of cases have never been collected at the same locality.

Many species of mantids are notoriously variable in adult structural characteristics, and for this reason, the writers do not feel that they at present possess series of adults large enough to warrant positive statements regarding possible differences between the two groups. Numbers, rather than specific names are thus applied to each group. The following designations are used in the present paper:

Species 1. Collections of oothecae indicate that this mantid occurs in most of west Texas, west of the 98th parallel of longitude. No oothecae have been collected east of this line. Representative collections of the egg cases of this species include: Electra, in Wichita County; Lubbock, Lubbock County; Seminole, Gaines County; Carlesbad, New Mexico; Fort Davis, Jeff Davis County; several

collections in Brewster County in the Big Bend area, and Del Rio, Val Verde County. The nymphs of this mantid are brown in their first instar. The egg masses are figured in Plate III, fig. 1.

SPECIES 2. This species is at present known only from southeast Texas, from San Antonio south and east to Brownsville. Collections of the oothecae of this mantid include San Antonio, Bexar County; Beeville, Bee County; Alice, Jim Wells County; Falfurrias, Brooks County; and Brownsville, Cameron County. The nymphs of this species are green in the first instar. The egg masses are illustrated in Plate III, fig. 2.

SPECIES 1. The oothecae of this mantid (Plate III, fig. 1) are easily distinguished from those of *S. carolina* and *S. californica*, since the former are larger and of a different shape.

The color varies from orange to black. Cases collected in central Texas have almost invariably been black, while those from west Texas have been orange in practically all instances. Not more than a half dozen of the several hundred oothecae of this species that have been collected have been exceptions to this rule. The difference between these two colors is so striking that when the writers first collected the orange colored cases they thought it probable that a species different from the black cases was involved. The orange colored cases were kept in the laboratory for a time, and the writers found to their amazement that most of the oothecae darkened perceptably, and some eventually became almost as dark as those collected in central Texas. This color change was noticeable after the oothecae had been in the laboratory for 24 hours, but most of them darkened considerably after this time. Old cases, or those collected relatively late in the season (after December) apparently do not possess the capacity for color change, since no noticeable darkening has been noted in oothecae that have been collected after the above date.

Although all the factors that may influence the color difference or that may have caused the darkening of the light colored cases are not known positively, it is thought probable that relative humidity and temperature may have been contributing factors. Most of the orange colored cases have been collected in areas where the rainfall is less than in the regions where the dark oothecae occur. Relatively high humidity in the Austin area, or the higher laboratory temperatures may have influenced the change in color.

An examination of the cross section reveals that only the middle tiers of cells are vertical with respect to the dorsal and ventral surfaces of the oothecae, while rather large air spaces occur dorsal and lateral to the outer layers of cells.

SPECIES 2. The oothecae of this species (Plate III, fig. 2) vary from a light to a dark reddish brown with an occasional specimen almost black. When these oothecae are first produced, the usual white deposit almost covers them. As the cases are exposed to the weather, most of the white material disappears except for two lateral longitudinal stripes, one on each side of the case near the top. These stripes are quite persistent in many instances, and may even be present in egg cases that have been exposed to climatic conditions for over a year. These white

stripes are absent or very faint in the oothecae of species 1, since in most instances, the whitish material disappears entirely after the cases have been exposed to the weather for a short time. The persistent white stripes of species 2 may be noted in Plate III, and it may also be seen that there is a difference in the shape of the two types of cases. Those of species 2 are on an average more slender and are not so high as are the oothecae of species 1.

In cross section, the arrangement of the egg cells is seen to be similar to that of species 1. Only the middle cells are perpendicular to the top and bottom of the case, while those on each side occur at an angle. Small air space may be noted lateral to the emergence area, and dorsal to the egg cells.

Roberts (1937a) studied the biology of a mantid which was determined as *Stagmomantis limbata* (Hahn), and the egg cases that were used in the investigation were collected in Arizona. The ootheca figured in this paper, and the description of the nymphs that emerged during the study closely resemble the oothecae and nymphs of species 2 of the present paper. It may be that these two species are the same, but further study must be completed before this fact can be determined with certainty. The fact that species 2 apparently does not occur in west Texas may be considered as some evidence that this species and the mantid studied by Roberts are not the same, but in Mexico the distribution of the two may be continuous or nearly so.

Brunneria borealis Scudd.

The oothecae of this species (Plate IV, fig. 1) differ radically from those of the mantids previously discussed. They are relatively small, are laterally compressed and they possess a definite dorsal point on the posterior end. The cases are quite compact and are noticeably harder than those of most species.

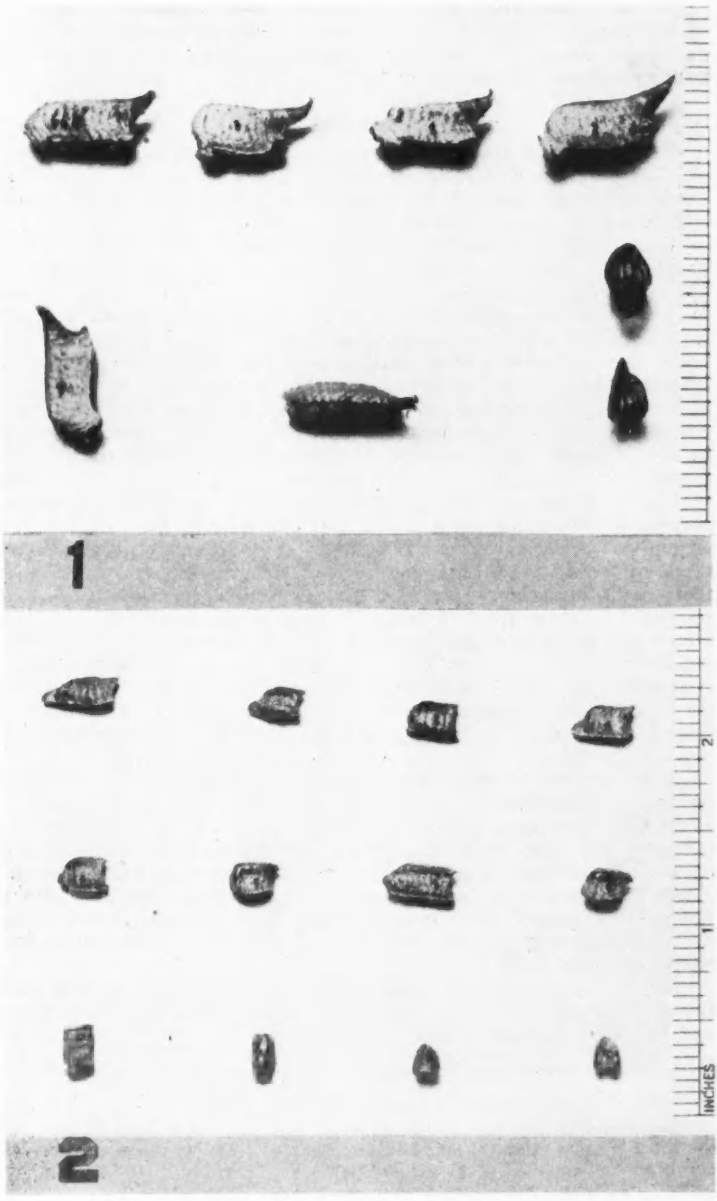
An interesting feature of this case is the presence of a ventral band of material on the anterior end that either partially or completely encircles the twig or weed to which the ootheca is attached. This band was not present in the few cases that the writers have collected from flat surfaces.

Upon hatching the young mantids emerge only from the point at the posterior end, and not from a large area along the dorsal surface as is true for most species. The hollow point connects to an inner cavity above the eggs with which the ends of the eggs are in contact. This modification of the emergence area is one of the most extreme modifications of oothecae that was observed during the entire study.

The egg cases are usually grey in color, but may have a yellowish cast, and they are occasionally almost black.

EXPLANATION OF PLATE IV

Mantid oothecae. FIG. 1. Ootheca of *Brunneria borealis* Scudd. Collected 5 miles southeast of Austin, Texas. FIG. 2. Ootheca of *Litaneutria minor* (Scudd.). Egg masses deposited in the laboratory by females collected 10 miles northwest of Burnett, Texas.


1
2
INCHES

The egg cells are perpendicular to the top and bottom of the oothecae, while air spaces are practically non-existent except for the dorsal space mentioned above into which the young mantids issue before they emerge from the hollow tip.

Litaneutria minor (Scudd.)

This species of mantid produces the smallest oothecae that have been seen by the writers (Plate IV, fig. 2). Only a few of these egg cases have been collected in nature, those that are illustrated having been deposited in the laboratory.

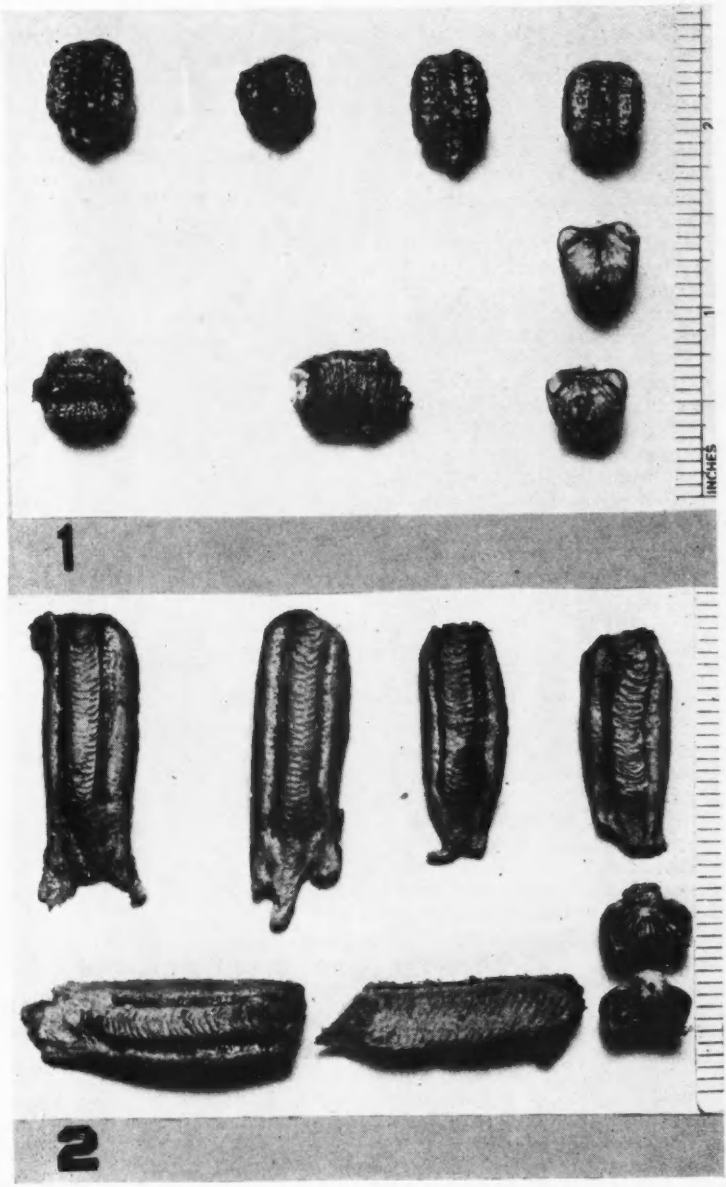
Roberts (1937b) describes the egg masses of this species, and he states that a captive female may deposit as many as ten oothecae. The writers do not have any accurate data as to the number produced by a single female, since because of limited facilities, several mantids were confined within a single container. These mantids survived longer than did most species, aside from *S. carolina*, and they deposited several oothecae while they were in captivity. The egg masses obtained by the writers correspond quite closely to the description of the external structure given by Roberts (1937b). The prevailing color is light brown or grey. Some specimens superficially resemble those of *B. borealis*, since they are laterally compressed, and a small dorsal point frequently occurs on the posterior end. The transverse partitions between the tiers of egg cells are extended dorsally, and these extensions form overlapping flaps in the emergence area somewhat resembling those in the oothecae of *S. californica*. Because of the small size of these cases, and the obscuring of the projections by the whitish substance secreted by the female at the time of egg deposition, the flaps are usually not evident in a newly deposited case unless it is examined with a hand lens or a dissecting microscope. Even with magnification, it is sometimes necessary to probe with a dissecting needle to observe the flaps. The emergence area is enclosed laterally by the projecting sides of the case so that the young mantids emerge at the ventral side of a shallow trough.

In some of the oothecae, particularly those of large size, the anterior portion of the emergence area is covered by the fusion of the two sides, so that these posterior cells do not have an independent opening to the outside. In these oothecae, nymphs emerging from the posterior cells must pass some distance anteriorly before issuing to the outside. There thus appears to be a distinct tendency for the oothecae of this species to approach the condition found in *B. borealis* in which the nymphs all emerge from the hollow point rather than from a large area along the dorsal surface.

An examination of the cross section of the egg case reveals that the egg cells are mostly perpendicular to the top and bottom surfaces, and that air spaces are practically non-existent.

EXPLANATION OF PLATE V

Mantid oothecae. FIG. 1. Oothecae of *Phyllovates chlorophaea* (Blanchard). Collected 6 miles north of San Benito, Texas. FIG. 2. Oothecae of *Tenodera angustipennis* Sauss. Collected at Lancaster, Pennsylvania.


INCHES
1
2
1
2

Phyllovates chlorophaea (Blanchard)

This species produces an ootheca (Plate V, fig. 1) that is easily distinguishable from those of other species that have been studied. The prevailing color is brown with an occasional specimen almost black.

The method of attachment of this egg mass to the substratum is probably the outstanding characteristic of the oothecae. In all other species that were studied, most of the mid-ventral surface of the egg case was in contact with the substratum. This is even true for the ootheca of *B. borealis*, a species that frequently encircles the supporting twig with a band of material attached to the ventral side of the anterior end of the case. The egg mass of *P. chlorophaea*, however, is attached only by a small portion at the anterior end, while the remainder of the ventral surface is not in contact with the substratum at all. The material of the egg case encircles the twig at the point of attachment. This band, however, does not protrude ventrally to such an extent as does the comparable band on the ootheca of *B. borealis*, but the ventral side of this circlet of material is essentially at the same level as the remainder of the ventral side of the case.

The emergence area occurs upon a definite ridge, while the sides of the case are somewhat projected dorsally on each side to about the same height as the ridge. These projecting sides are the result of enlarged air spaces within the case, and these may be seen in cross section.

In cross section, the oothecae exhibit a distinct wedge shape, with the dorsal region wider than the ventral portion. This size discrepancy is obviously caused by the enlarged dorsolateral air spaces mentioned above. Only the central egg cells are perpendicular to the dorsal and ventral surfaces.

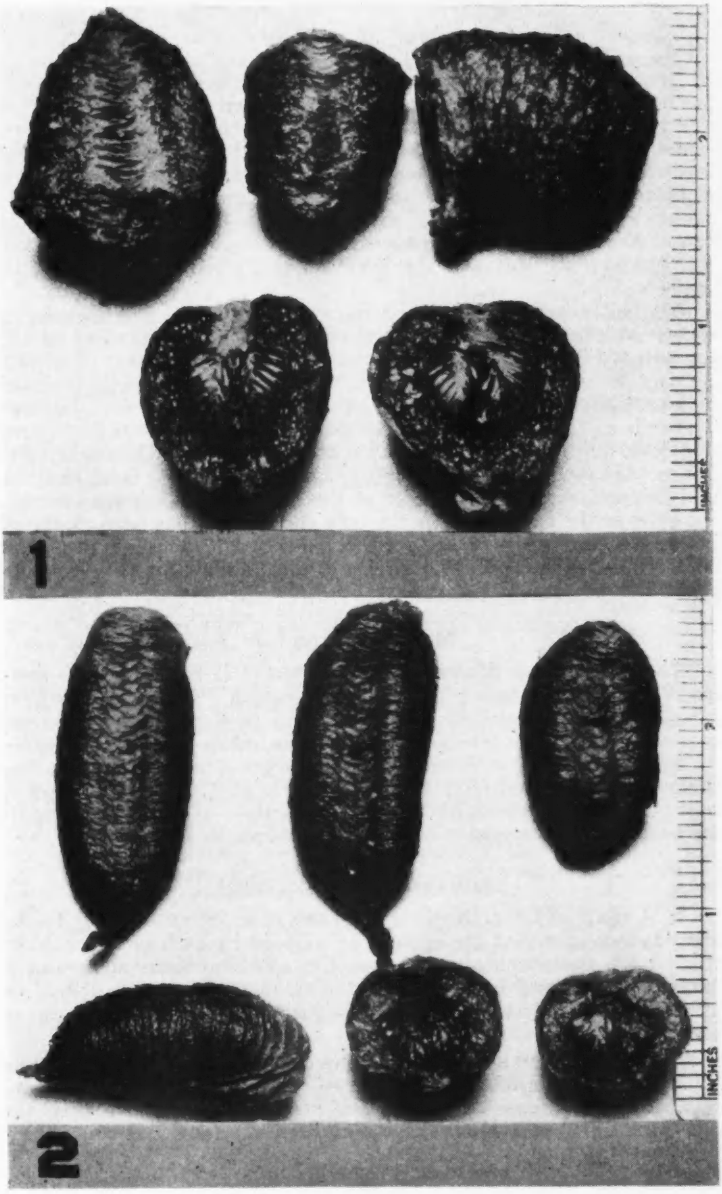
Tenodera angustipennis Sauss.

Jones (1933) has published an illustration of the egg masses of this mantid. Superficially, the structures resemble those of *S. carolina*, although the oothecae of *T. angustipennis* (Plate V, fig. 2) are normally larger. There is frequently a relatively long posterior portion of the case that does not contain eggs, a condition not developed to such an extent in the other species examined. The emergence area occurs in a definite ridge that projects somewhat above the sides of the case. The general color is brown, and the oothecae usually possess a dark stripe on each side of the emergence area.

In cross section it is observed that only the center cells are at right angles to the base. Air cells are almost entirely absent so that the structure is quite hard.

EXPLANATION OF PLATE VI

Mantid oothecae. FIG. 1. Ootheca of *Tenodera aridifolia sinensis* Sauss. Collected at Lancaster, Pennsylvania. FIG. 2. Ootheca of *Mantis religiosa* L. Collected at Rochester, New York.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INCHES

Tenodera aridifolia sinensis Sauss.

This species produces one of the most outstanding egg cases studied by the writers (Plate VI, fig. 1). The structures have been illustrated by Jones (1933) and many individuals in the East, where the species has become established, are probably familiar with the oothecae. They average larger than the egg masses of any other species that have been examined. The color is greyish to brown, and the shape is somewhat irregular, although there is a tendency for the cases to assume a roughly globular outline. This comparative shape irregularity is probably caused by the numerous small air spaces in the thick outer layer of the case. As a result of these air spaces, which are evident in cross section, the oothecae are soft and the sides are easily indented with a little pressure.

The ootheca is wedge-shaped in cross section with the base being somewhat smaller than the dorsal region. The arrangement of the egg cells is different from that of any of the species previously discussed. As may be noted in the illustration, there is one row of cells arranged in a partial circle around a few that occur at the center of the case. The cells in the middle of the ootheca form two rather definite rows in a dorso-ventral plane. Only a few of the individual cells are vertical, but most of them are arranged at an angle, with the base being near the mid-line and with the remainder of the cell extending upward toward the sides of the case. This is the only species that has been examined in which several layers of cells occur dorso-ventrally, although the center cells of the oothecae of *M. religiosa* exhibit a slight tendency toward this condition.

Mantis religiosa L.

The oothecae of *Mantis religiosa* (Plate VI, fig. 2) are in some respects similar to those of *T. aridifolia sinensis*. The cases are soft as a result of many internal air spaces, and they are easily squeezed between the fingers. The prevalent color is brown.

In cross section, it is seen that the egg cell arrangement is also similar to the condition found in the oothecae of *T. sinensis*. A row of cells partially encircles a few cells in the center. Those in the middle are nearly at right angles to the top and bottom of the case.

SUMMARY AND CONCLUSIONS

1. A study of the oothecae or egg cases of several species of preying mantids indicates that the egg cases produced by each of the mantids studied are quite characteristic for the species. Since all available data should be used in taxonomic studies, mantid oothecae should be utilized to the fullest extent in investigations involving this group of insects.

2. At the present state of our knowledge, the oothecae of *S. carolina* appear to be less specialized than those of the other species that were studied. An egg case of this general structure could have been the type from which other forms have been derived.

3. Evidence is presented that the mantids in Texas now recognized as *Stagmomantis limbata* (Hahn) represent two distinct species. Reasons for this conclusion include distinct types of oothecae, nymphs of different color in the first instar and different distributions of the two mantids.

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CHEMICAL INSECT ATTRACTANTS AND REPELLENTS, by VINCENT G. DETHIER. xv+289 pages, 69 figures. The Blakiston Company, Philadelphia, Pa., 1947. Price $5.00.

The author states his objectives so carefully in his preface that readers are left in no doubt of the nature of this book. Dr. Dethier does not propose a compilation of formulae and methods of application nor a detailed study of the physiology of the insect but attempts "to bridge the borderline between chemoreception and the broader aspects of behavior based upon it."

The book opens with a chapter on the history of the subject. Chapters two to five cover various types of attractants. Chapter 6 deals with olfactometers and threshold concentrations, chapter 7 with baits and traps, and chapter 8 with repellents. In chapter 9 on the chemical basis of taste and olfaction and chapter 10 on the evolution of feeding preferences the author departs from more factual topics to take up those involving difficult interpretation and many unknowns.

The author shows remarkable comprehension of his subject. All parts of his work will offer an abundance of information to the entomologist and most chapters are of considerable interest to biologists in general. The last two especially have broad significance, even though they are based primarily upon insects. They reveal high competence in the handling and interpretation of facts as the preceding chapters reveal the breadth of the foundations on which the book is based.

Each chapter is accompanied by an impressive bibliography and the book concludes with author and subject indices.

In the reviewer's opinion Dr. Dethier has made an important contribution in this study to the development of a precise science of entomology which has been going on during the past few decades. As much of the earlier material based on trial and error and on simple observation has yielded to more elaborate scientific methods our science has become so complex that specialists know less and less of each others' fields. Books like Dr. Dethier's fill an important place in making more up-to-date knowledge conveniently accessible.—A. W. L.

THE WEIGHTS OF PHYMATA PENNSYLVANICA AMERICANA MELIN

(Phymatidae, Hemiptera)[1]

W. V. BALDUF,
Urbana, Illinois

This study was done simultaneously with that on the weights of *Sinea diadema* (Fabr.) described in number 4 of volume XL of these ANNALS, and followed the same general plan. The four diets used, A to D, are explained in the legends for Tables I and II. The results are presented under the same topics employed for *Sinea* in order to facilitate comparison. The data offered below are derived from daily weights of 40 individuals.

RESULTS

Range of Weights of Nymphs.—In the absence of a balance that permits accurate weights of the newly-hatched nymphs, I employ the single value of 0.0003 gram for all such individuals. As a sort of guess indicated by actual attempts at weighing the nymphs, this figure probably errs on the upper side. Table I presents data which indicate the capacity of the species to vary in weight in accordance with different instars, diets and sexes. The variations are expressed in terms of the average and extreme last daily weights for each instar. It will be seen that an impressive range in weights occurs, even among individuals of one sex and diet. This is most obvious in the fifth instar, where the spread between the lightest and the heaviest individual in each dietary group reaches its peak. In general this spread is greater among the female nymphs; they consume more prey and attain a larger bulk in the course of growth than the males. In their mature state, reached at the end of the fifth instar, the 26 male nymphs in all dietary groups varied from 0.0224 to 0.0258 gram, while the 16 females varied from 0.0334 to 0.0473 gram. In the entire course of development, the male nymphs varied in multiplying their weights between 76 (diet C) and 87 (diet D) times, the females from 112 (diet D) to 159 times (diet B). In terms of percents of average gains from hatching to nymphal maturity, the males ranged between 7,490 and 8,527 and the females between 10,136 to 15,900 percents.

Range in Weights of Adults.—The pertinent data are given in Table II. The results are segregated by sex and diet, and expressed in terms of average duration of the adult life, percent of increase or decrease (1) from the first to the last day of adulthood and (2) from the first ten to the last ten days. The most diverse differences in percent of change are obtained when the weights of the first and last days are compared, the males displaying an average gain of 1.36 to

[1]Contribution No. 276 from the Entomological Laboratories of the University of Illinois. This investigation was financed by the Graduate School of the University.

12.5 percent. But when the average weights of the first ten and last ten days are used as bases, the same males lost 4.04 to 5.23 percent of their weights. Similar differentials obtain among the females, although here the results derived from both methods (1 and 2, above) of expressing the range in weights are positive. The percents of loss and gain correlate roughly with the amount of food, duration of adult life, and the number of eggs produced by the females. These numbers embrace both eggs laid and those secured by postmortem dissections.

Regardless of dietary group, the reared males varied in weight from 0.0185 gram to 0.0391 gram, the females from 0.0315 to 0.0628 gram. Invariably the adult weighs least on the first day when it has suffered its extreme from molting and has not yet resumed feeding. The peak weight is attained at various time points in adulthood. If the nymph was underfed, the adult lives only a few days and experiences its maximum weight relatively early. The better to optimally-fed adults achieve their maxima generally after ten days and may reach or approach those figures repeatedly thereafter. In not a few cases, the peak weight is reached after midlife. The females make much larger gains than males when well fed, this apparently being an inherent intersexual difference implemented by the greater avidity characteristics of the females.

Weight Pattern of the Nymphs.—The increases and decreases that characterize the weight of nymphal *Phymata* in the course of the instar are essentially the same as occur in *Sinea*. Curves *a* to *e* on figure 1 represent five of the forty individual life histories that were secured in this study; they are not based on the actual or raw weights but on the percents of the daily gains and losses. It will be observed first that the curves for the first instar are identical in all the five instances. They were arbitrarily made so because the balance used was not sufficiently refined to secure accurate weights of the first instar bugs. There is some evidence that *Phymata*, like *Sinea*, does not feed in the first and second days of the first instar. Accordingly the nymph doubtlessly loses some weight during those days, hence the line representing the first day on the curve was made to slope down from the horizontal.

Each instar consists of (1) a feeding-growing phase and (2) a molting phase, with the result that the over-all curve for each instar forms an attenuated capital S. The physiological facts underlying this form of the curve are as follows: the feeding-growing phase begins hours to a day or so after the molt. As a consequence of the semi-dessicated state of the tissues resulting from losses of substances in the molt, the nymph ingests a relatively very large amount of food on the first day of this phase, thereby increasing its weight 60 to 83 percent over that of the previous day. On the second day, intensive feeding continues but at a decreased rate with gains of 12 to 30 percent. On the whole the feeding and gains fall still farther below this on the third and succeeding days of the instar, and eventually are discontinued on the last one or two days preceding the next molt. Because feeding ceases for a period immediately before the molt, the nymph actually loses weight perceptibly at this point of the phase. The feeding-growing phase is here regarded as ending with cessation of feeding and

TABLE I

GRAM WEIGHTS OF NYMPHS, BY INSTARS, DIETS AND SEXES

Diets	Sex	Numbers Weighed	First Instar		Second Instar		Third Instar		Fourth Instar		Fifth Instar	
			Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights
A	♂	8	0.0010	0.0007 0.0014	0.0020	0.0016 0.0026	0.0055	0.0042 0.0068	0.0137	0.0110 0.0166	0.0244	0.0193 0.0276
B	♂	4	0.0008	0.0007 0.0009	0.0021	0.0018 0.0023	0.0054	0.0049 0.0057	0.0127	0.0116 0.0136	0.0245	0.0228 0.0265
C	♂	3	0.0008	0.0007 0.0009	0.0020	0.0014 0.0024	0.0055	0.0041 0.0072	0.0123	0.0095 0.0155	0.0227	0.0195 0.0260
D	♂	11	0.0009	0.0008 0.0012	0.0023	0.0018 0.0028	0.0059	0.0050 0.0068	0.0136	0.0111 0.0162	0.0261	0.0219 0.0305
A	♀	9	0.0011	0.0007 0.0012	0.0027	0.0022 0.0040	0.0068	0.0052 0.0083	0.0173	0.0135 0.0214	0.0375	0.0308 0.0470
B	♀	1	0.0010	0.0010 0.0010	0.0030	0.0030 0.0030	0.0092	0.0092 0.0092	0.0231	0.0231 0.0231	0.0477	0.0477 0.0477
C	♀	2	0.0009	0.0008 0.0010	0.0023	0.0023 0.0023	0.0070	0.0063 0.0077	0.0175	0.0165 0.0184	0.0368	0.0334 0.0402
D	♀	4	0.0010	0.0008 0.0011	0.0021	0.0017 0.0023	0.0064	0.0061 0.0067	0.0161	0.0129 0.0184	0.0337	0.0255 0.0378

EXPLANATION OF DIETS: A, maximum *Drosophila* in all instars; B, maximum *Drosophila* in first three instars, and maximum *Drosophila* alternated daily with maximum *Musca* in instars four and five; C, maximum miscellaneous insects from fields in all instars; D, maximum *Drosophila* in first three instars, and maximum *Musca* in instars four and five.

TABLE II

WEIGHTS OF ADULT *Phymata*

Diets	Sex	Number Weighed	Average Life in Days	Average Weight in Grams		Percent Change, First to Last Day	Average Weights in Grams			Percent Change, First 10 to Last 10 Days	Average Number of Eggs Produced
				First Day	Last Day		First 10 Days	Middle 10 Days	Last 10 Days		
A	♂	2	63	0.0216	0.0243	12.5 gain	0.0236	0.0247	0.0236	0.0000	.....
B	♂	4	112	0.0228	0.0253	10.9 gain	0.0272	0.0266	0.0261	4.04 loss	.....
C	♂	3	107	0.0215	0.0237	10.2 gain	0.0251	0.0250	0.0238	5.18 loss	.....
D	♂	4	111	0.0294	0.0298	1.36 loss	0.0325	0.0302	0.0308	5.23 loss	.....
A	♀	8	58	0.0350	0.0426	21.7 gain	0.0383	0.0478	0.0457	19.3 gain	3.9
B	♀	1	78	0.0467	0.0756	61.7 gain	0.0607	0.0815	0.0801	40.0 gain	59.0
C	♀	2	97	0.0346	0.0569	65.0 gain	0.0459	0.0588	0.0589	28.3 gain	178.0
D	♀	1	142	0.0354	0.0577	63.0 gain	0.0522	0.0590	0.0612	17.2 gain	275.0

EXPLANATION OF DIETS: A, maximum *Drosophila* daily; B, maximum *Drosophila* and *Musca* on alternate days; C, maximum miscellaneous field insects daily; D, maximum *Musca* daily.

inception of the decline in weight. It occupies approximately three-fourths of the time of the whole instar.

The molting phase of the instar begins where feeding and increase in weight cease. Ideally the curve for this phase should invariably

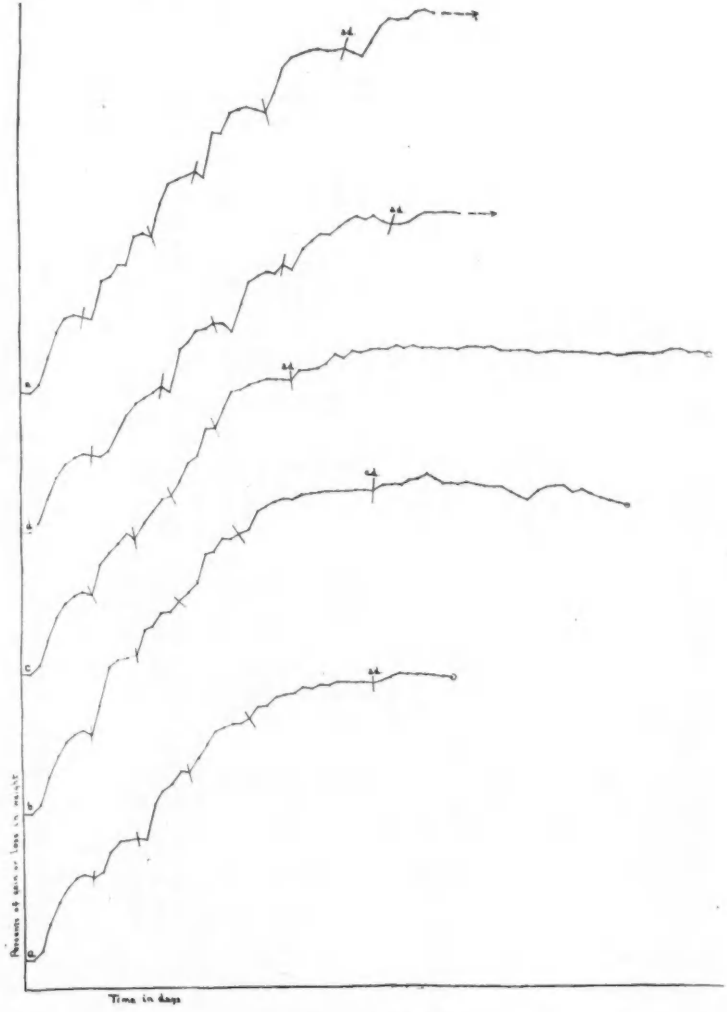

FIG. 1, a, b, c, d.

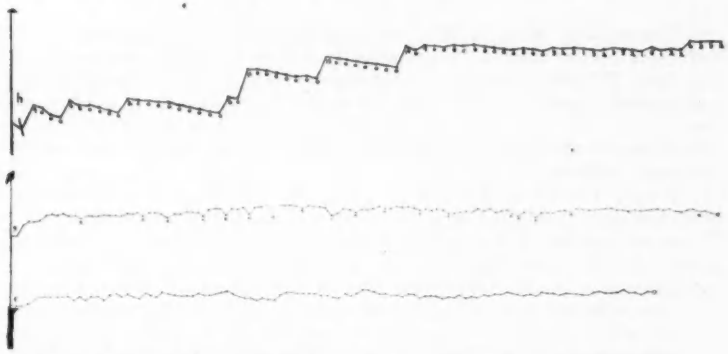

FIG. 1. Weight patterns of *Phymata* maintained on two different diets.
a. Male. Diet A.
b. Female. Diet A.
c. Female. Diet D.
d. Male. Nymphal life only. Diet D.
e. Female. Nymphal life only. Diet D.
f. Male. Adult life of nymph d. Diet D.
g. Female. Adult life of nymph e. Diet D.
h. Fifth instar nymph on manipulated diet of *Drosophila*.

NOTE: The transverse lines on the curves mark the limits of the instars. The letter *e* on curve *g* indicates eggs were laid; *ad* signifies adult stage begins; the circles at the end of the curves indicate death of the bug, and the arrows terminating curves *d* and *e* indicate that the adult life of these individuals is represented on curves *f* and *g* respectively. Note that the first 8 and 10 adult days are duplicated on *e* and *g*, and *f* and *h*, respectively. The figures at the daily dots of curve *h* state the number of *Drosophila* sucked out.

show a slight decline for the time preceding the molt because failure to feed results in a drop in weight. Next, the nymph suffers a sharp slump in weight due to the shedding of the old cuticle and the attached parts and a high rate of evaporation from the new soft moist cuticle. No food can be taken at this time, presumably because the skeleton and its internal continuations, as tracheal and gut linings and the feeding stylets, remain soft. Presumably molting also temporarily inhibits the usual functions of other physiological mechanisms. When the newly formed chitinous parts become set, feeding is resumed, this beginning usually in somewhat less to more than 24 hours after the molt.

The maximum losses in weight incident to the molting phase sustained in the 4–5 ecdysis were 0.0017 gram, and those of the 5–adult molt 0.0029 gram. The average weight of 26 dry exuviae from both sexes in the 4–5 molt was 0.000238 gram, and that of 22 from the 5–adult molt 0.000543 gram. On the basis of these data, the dry exuviae represent 14 percent of the loss in the 4–5 molt and 19 percent in the 5–adult molt. Accordingly, the remaining 86 and 81 percents, respectively, are traceable to evaporation, largely from the soft moist new cuticle and but little during the pre-molt part of the phase. In as much as these percents are based on small samples that take no account of sexual differences, they are to be accepted as indicative only.

The slender S-form of the instar curve is therefore explained (1) by extensive rise in weight that results from heavy to light feeding during the first three-fourths of the feeding-growing phase and (2) by the subsequent loss of 10 to 12 percent of the body weight incident to the molting phase. Since the loss in any one instar is offset strongly by the gains, the curve of growth makes a steep net rise during the nymphal stage as a whole.

Weight Pattern of the Adult.—Curves *f* and *g*, figure 1, represent respectively a male that lived 111 days and a female that lived 122 days. These are comparatively long lifetimes for reared *Phymata*. The female produced 275 eggs, which number approaches the average obtained in my previous life history work (1941). For these reasons, this pair may be regarded as exhibiting most nearly the features characteristic of the weight pattern of this species. Again, as in *Sinea*, this pattern consists essentially of three phases. The first extends through the one or more days following the 5–adult molt, when the still soft moist adult loses considerable weight from evaporation and failure to feed. This is the molting phase. The second phase begins when the new structures harden and the adult begins to feed. It occupies several successive days, during which the weight climbs from the previous low to the high level that persists throughout the rest of adulthood. This phase is characterized by its limited duration, the sharp and extensive rise in weight and the most prolonged intensive feeding the adult engages in. It may perhaps be called the transition phase. The intense feeding is probably actuated by the semidessicated state of the inner body that resulted from the recent molt. During this phase the adult appears to store the reserve nutrients essential to the genesis of the first sperms and eggs. The third phase consumes the largest part of the time and energy of the adult life, and may be described as the feeding-producing phase. Two other prominent features of this period are the approximately horizontal direction assumed by the curve, and the somewhat periodic drops and rises in weight, which, however, do not depart far from the horizontal mean. The variations in the female weights are sharper and more regularly spaced than in the male, and are brought about chiefly by the functions of feeding, defecation and oviposition. The deposition of the eggs in mass form, rather than singly, contributes significantly to the sharpness of the variations; the sharpness is due not only to the drops resulting from discharge of the masses, but perhaps also to the equally sharp and prompt increases in feeding that follows oviposition. The pattern suggests that the build-up from feeding and oögenesis alternates with loss from oviposition and elimination of feces, or that the accumulation of the maturing eggs in the ovarian tubes temporarily inhibits feeding. This inhibition might be implemented by depression of the alimentary tract by the egg mass whereby the storage capacity of the tract might be reduced. The hungry state brought about thus may then stimulate the short period of intense feeding that follows oviposition. This theory was not tested by dissections of gravid females.

It is of interest too that the larger masses of eggs were yielded in the first half of life, and mostly at intervals of four or five days. By contrast, smaller masses were laid at longer and less regular intervals during the third quarter, and deposition virtually ceased in the last

fourth. The presence of 36 mature eggs in the tubes of the dead bug indicates that oögenesis continued to some extent to the very end of life. This mass of retained eggs obviously served materially to keep the weight at a uniformly high level to the end, and possibly inhibited feeding to a degree that contributed to death.

The rises and drops in the weight of the male are less regular and sharp than in the female, and they tend to flatten out after mid-life as in the case of the female.

Finally it may be noted that the adult life of the bugs represented on curves *a*, *b* and *c* differ from *f* and *g* chiefly in being shorter, and that of the males in particular varied less in the vertical dimension in accordance with their comparatively little sexual performance. These graphed examples are more or less typical of the other weight histories obtained.

Weight Pattern of a Nymph on Manipulated Diet.—One nymph of a series scheduled to receive a minimum diet of *Drosophila* chanced to be provided that particular amount of food which produced an extraordinary attenuation of the fifth instar. Whereas the nymphs of *Phymata* ordinarily spend 12 to 15 days in this instar, the above individual remained in that stage for 71 days and was still vigorous when it was deliberately cyanided. In the course of its life in this instar, the bug increased from 0.0060 gram on the first post-molt day to 0.0222 gram on the 70th day. *Drosophila* were supplied at irregular times and in irregular numbers, as I have indicated beneath the day dots on curve *h*, figure 1.

Rate of Progression in Nymphal Growth.—The growth quotient, adopted here as a means of expressing the rate of progress in nymphal growth, is explained in my article on *Sinea*. The pertinent data for all individuals that lived to the adult stage are given in Table III. These are stated as averages and extremes for each instar and for the nymphal stage as a whole, and are classified according to diet and sex. Also the weights of the exuviae, presented in Table IV, bear on the rate of progression.

On the whole, the pattern of progression in *Phymata* is essentially like that of *Sinea*. The chief features follow. First, the growth quotient for the first instar tends to be greater than the quotients of instars two to five, despite the assumption of 0.0003 gram, which will probably prove too high; and this difference is more pronounced in the females. Second, the lower quotients of fifth instar males indicate that diets A, B and C were inadequate, probably through the inaptitude of these larger nymphs in securing small prey, i.e., *Drosophila*. Compared with the females, these lower quotients reflect also the greater avidity with which the females feed even before they become adults. Third, the quotients for any one instar, sex and diet exhibit a wide range, thus emphasizing the extensive individual variation of which the species is capable. Fourth, most of the average quotients exceed 2.0, hence do not conform closely to Przibram's principle of doubling, but vary from 1.9 to 3.9. The growth rates indicated by the weights of the exuviae (Table IV) are more nearly uniform than those of the whole insects. This may be due in part to the inclusion of the exuviae of well-fed nymphs only, whereas whole nymphs provisioned at varied dietary rates figure in the calculations in Table III.

TABLE III

GROWTH QUOTIENTS OF *Phymata**

Diets	Sex	Nymphs Weighed	AVERAGE AND EXTREME GROWTH QUOTIENTS					
			First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage
A	♂	7	3.2 1.7-4.7	2.3 1.8-3.6	2.4 1.8-3.2	2.3 2.1-2.6	1.8 1.6-2.0	80.0 64.0-92.0
B	♂	4	2.6 2.3-3.0	2.6 2.0-3.3	2.5 2.1-3.0	2.6 2.5-2.7	1.9 1.5-2.2	82.0 76.0-88.0
C	♂	3	2.6 2.3-2.7	2.5 2.2-2.8	2.7 2.4-2.9	2.1 1.8-2.6	1.8 1.6-2.1	76.0 65.0-87.0
D	♂	4	2.9 2.3-3.7	3.1 2.6-3.1	2.6 2.3-3.1	2.5 2.4-2.7	2.2 2.1-2.4	94.0 87.0-102.0
A	♀	9	3.5 2.3-5.3	2.7 2.0-3.8	2.3 1.7-3.1	2.5 2.2-3.2	2.1 2.0-2.4	125.0 103.0-157.0
B	♀	1	3.3	2.3	3.5	2.8	2.2	159.0
C	♀	2	3.9 3.7-4.0	2.2 1.7-2.6	2.0 1.8-2.3	2.6 2.4-2.8	2.2 2.1-2.3	122.0 111.0-134.0
D	♀	1	3.0	3.3	1.7	2.5	2.6	124.0

*For explanation of diets, see legend, Table I.

TABLE IV

WEIGHTS OF EXUVIAE. WELL-FED *Phymata*

Exuviae from Molt Number	Number of Exuviae Weighed	Total Weight of Exuviae in Grams	Average Weight of Single Exuviae	Growth Quotient
1–2	35	0.00087	0.0000248	...
2–3	35	0.00145	0.0000414	1.7
3–4	29	0.00290	0.0001000	2.4
4–5	26	0.00620	0.0002380	2.4
5–adult	22	0.01195	0.0005430	2.3

The rate of progression may be expressed also in terms of the net weights gained in the several instars. The net gain is the value secured by subtracting the first day weight from the last day weight of each instar. The sum of the five net weights constitutes the total net gain made during the entire nymphal or growth life of the bug. This sum was then employed as the base figure in determining the amount of

weight, in percents, contributed to the nymphal total in each of the instars. If the rate of progression followed closely the Przibram doubling principle, the net weights gained in the five instars would be 3.125, 6.25, 12.50, 25.00 and 50.00 percents, respectively. Reference to my data for 34 nymphs in Table V will show that the pattern of progression only approximates the ideal one given above. They indicate further that fifth instar males on diets A, B and C contribute less to the total net gain of the whole nymphal stage than the better fed individuals of diet D or the more avid females of the same instar.

Departures from the ideal proportions may be attributed to failure to take the weights at precisely the lowest point, at the beginning, and

TABLE V

INSTAR CONTRIBUTIONS TO TOTAL NET WEIGHT OF NYMPHS, IN PERCENTS

Diet	Sex	Number Weighed	AVERAGE AND EXTREME PERCENTS, BY INSTARS				
			First	Second	Third	Fourth	Fifth
A	♂	6	2.7 1.4-3.5	4.5 3.5-6.2	13.7 10.2-18.5	32.38 26.25-35.00	46.17 40.00-55.88
B	♂	4	2.6 2.2-3.0	6.0 4.8-7.8	10.6 8.4-17.4	33.21 27.20-40.09	45.16 35.21-52.07
C	♂	2	2.8 2.3-3.2	6.3 5.5-7.0	17.8 17.7-17.9	30.2 28.0-32.4	42.94 41.79-44.09
D	♂	10	2.8 1.7-4.4	4.97 3.8-9.0	13.36 10.3-15.1	28.14 20.3-34.0	50.97 47.30-54.24
A	♀	6	1.9 1.5-2.4	4.4 3.6-5.1	11.75 9.6-13.2	29.24 26.63-32.00	53.12 50.00-57.91
B	♀	1	1.6	3.5	13.4	29.5	52.03 .....
C	♀	1	2.6	4.1	9.7	31.02	52.59 .....
D	♀	4	1.9 1.8-2.0	3.6 3.1-4.3	11.2 7.1-17.4	28.75 24.50-33.70	54.57 50.00-62.26

the highest point, at the termination of the instar; to irregular pro- the possibility that some individuals may feed sparingly in one instar, then feed more heavily, or "catch up," in the next. On the other hand, these departures may be natural and normal to the species. visioning; to hereditary differences between the individuals, and to

DISCUSSIONS

Periodic Weights.—Since the purpose of weights is to secure a complete and correct picture of the changes in bulk, and to measure the amount of the changes occasioned by the several contributory

factors, it must be apparent that only continuous second by second records can approach achieving these objectives. For instance, securing the correct growth quotients depends on getting the lowest post-molt weight and the highest pre-molt weight of each instar. Periodic weights reflect only the status of the organism at the times of weighing. As a consequence, the investigator is obliged to make assumptions regarding the nature and extent of the intervening events or to disregard the problems involved. By the periodic method, correct data are obtained now and then but only by the chance that the experimental organism be weighed at the critical moment, with the result that most records taken involve some degree of error. Yet daily weights come nearer reflecting the nature of the vital phenomena than do weights taken at longer intervals.

Despite the desirability of continuous weight records, it seems improbable that man can devise a machine automatically capable of isolating and recording the amount of the gains and losses due to such physiological functions as reproduction, digestion, respiration and molting.

Comparison of Sinea and Phymata as Experimental Bugs.—Despite efforts made to provide the amount of *Drosophila* and *Musca* requisite for the maximum biological performance of *Sinea*, this objective was probably realized but rarely. By contrast, the best-fed *Phymata* at least approached that goal more closely. The reasons for this difference in performance are fairly obvious, since they occur in the relative adaptiveness of the two forms for predation. The fourth and fifth instar nymphs and the adults of *Sinea* bear long spiny forelegs which are comparatively inept in the capture of flies so small as *Drosophila*, and, on the other hand, these forms definitely evade the onrushing boisterous *Musca*. The curves for these instars are therefore less steep than those for instars one to three, which fact suggests the need for a third prey species between *Drosophila* and *Musca* in size. The corresponding nymphs of *Phymata* capture both flies with relative facility and do not require an intermediate species of prey to perform well in captivity. *Sinea* possesses the advantage that it feeds on flies newly inactivated with cyanide, but seems to accept them only when inordinately hungry, hence fails to achieve its best performance on this fare. *Phymata* makes the grasping response only when stimulated by moving objects.

SUMMARY

Series of *Sinea diadema* and *Phymata pennsylvanica americana* were caged and fed individually under controlled conditions and differentiated fares from hatching to death of the adult. Daily individual weights provided data pertinent to the following aspects of life:

1. Average and extreme weights that show the variability in bodily bulk of both nymphs and adults;

2. The pattern of normal rises and drops in weight, which indicate the nymphal stage consists of a feeding phase and a molting phase, while the adult life embraces three somewhat distinct phases;

3. The relative amounts of weight changes occasioned by various factors, but ingestion and molting in particular;

4. Daily losses sustained by a series of adult male *Sinea* deprived of food, and the weight history of a fifth instar *Phymata* which was fed a minimum diet and lived 71 days, when it was killed;

5. Growth quotients, which bear on the rate of increase or progression in weight from instar to instar, and indicate that these bugs only roughly approximate the principle of doubling stated by Przibram and Megusar;

6. The amount, in percents, of weight contributed by each of the five instars to the total net nymphal gain; this is another method of expressing the progression principle;

7. The limitations of periodic weights indicate the desirability of improved weighing methods that will reveal more precisely the characteristic features of the entire weight picture;

8. Relative merits and shortcomings of *Sinea* and *Phymata* as laboratory species for weights studies.

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THE WEIGHTS OF SINEA DIADEMA (FABR.) (Reduviidae, Hemiptera)[1]

W. V. BALDUF
Urbana, Illinois

The changes in volume sustained by insects during their postembryonic life have been investigated in three ways: by calculating the amount of water displaced by submerged specimens (Yagi), by measuring the dimensions of the whole or parts of the body, and by weighing the exuviae and/or the entire organism. The scientific results obtained by these techniques have already been adequately reviewed by Abercrombie, Bodenheimer (1932, 1933), Calvert, Harries and Henderson, Hodge, Lincoln, Ludwig and Yagi.

In the present study of the weight pattern of the common assassin bug, *Sinea diadema*, at Urbana, Illinois, five lots of individuals were reared during 1942 to 1944. Each bug was caged and fed individually, and kept at 80° Fahrenheit and a relative humidity of about 80 per cent. Differential feeding was employed in order to learn its effects on the growth-weight pattern of the bugs. The experimental individuals may be regarded as constituting the following three classes when separated according to the approximate amount of adult *Drosophila melanogaster* Meig. and *Musca domestica* L. allowed in the diet of the nymphs and adults: (1) bugs allowed enough *Drosophila* to bring them hardly to the adult state (diet X); (2) bugs given all the *Drosophila* both nymphs and adults were able to utilize (diet A), and (3) bugs supplied all the *Drosophila* they could use as nymphs, and all the *Musca* the adults were able to use (diet D). The bugs failed to achieve their maximum biological performance even on the most adequate diet D.

While all individuals concerned here were weighed daily, complete records, from hatching to death, were not taken on all of them. Some of the series were weighed throughout the postembryonic life, others only during the nymphal stage or in the fourth and fifth instars, and still others only as adults. This report is based on such more or less complete weight histories of 195 individuals. All weights were taken on a Chainomatic balance sensitive to one ten-thousandth gram. The curves (fig. 1, *a–g*) are based upon the percent of loss and gain sustained by the insect from day to day, and not on the absolute changes reflected by the daily weight records.

RESULTS

Range in Weights of Nymphs.—Like all heterometabolous insects, *diadema* undergoes a large increase in bulk in the course of development. The question, "How much does the bug weigh?" is therefore

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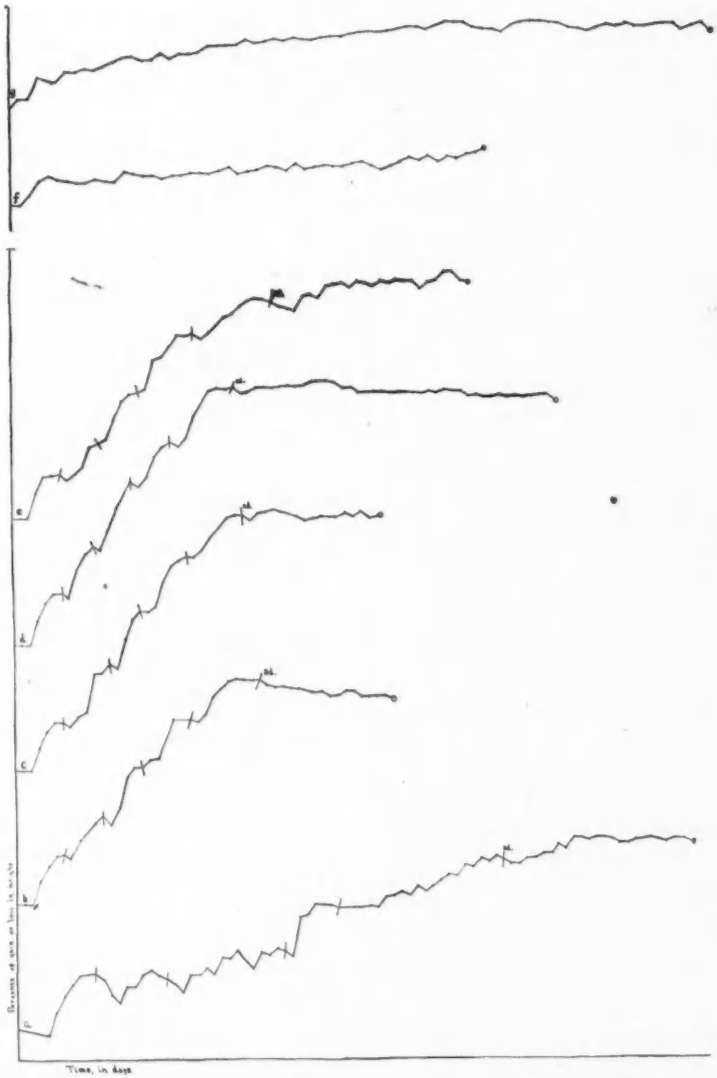

FIG. 1. Weight patterns of *Sinea* maintained on three different diets.

a. Male. Diet X.
b. Male. Diet A.
c. Male. Diet A.
d. Female. Diet A.
e. Female. Diet D.
f. Male adult. Diet D.
g. Female adult. Diet D.

NOTE: The transverse lines on the curves mark the limits of the instars; *ad* stands for adult, and the circles at the end of the curves indicate death of the bug. Curves *a* to *e* represent both nymphal and adult life; curves *f* and *g* only adult life.

TABLE I

RELATION OF DIET TO WEIGHT OF ADULT *Sinea*

Diet	Sex	Number of Adults Weighed	Average Life in Days	Average Weight in Grams		Percent Change First to Last Day	Average Weights in Grams			Percent Change First 10 to Last 10 Days
				First Day	Last Day		First 10 Days	Middle 10 Days	Last 10 Days	
X	♂	10	7.5	0.0163	0.0147	9.8 loss	.....	.....	.....	.....
A	♂♂	13	42	0.0299	0.0228	23.7 loss	0.0309	0.0300	0.0283	8.4 loss
D	♂♂	16	56	0.0298	0.0353	18.6 gain	0.0295	0.0300	0.0310	5.1 gain
X	♀	All female	bugs on this	diet died as	nymphs. U	nderfed.				
A	♀♀	7	31.4	0.0388	0.0324	16.5 loss	0.0409	0.0380	0.0344	15.9 loss
D	♀♀	16	57.5	0.0370	0.0518	28.6 gain	0.0433	0.0484	0.0511	15.26 gain

answerable by a series of numbers that express the amount and direction of the changes from day to day and stage to stage. Moreover, individuals of a series do not produce identical weight records during their growth, for significant variations associated with sex, amount of food taken, and possibly heredity, occur constantly. The single value 0.00027 gram is employed here for the weight of the newly-hatched unfed nymphs. This number represents the average obtained from weighing 62 individuals collectively. Progress in the weight of the nymphs, and an indication of the inter-individual variations in weight traceable to differences in sex, food and possibly heredity, are expressed by the following records for a series of 45 nymphs on diets X, A and D. The mature, about-to-molt nymphs of the first instar varied in weight from 0.0006 to 0.0014 gram; those of the second from 0.0010 to 0.0030; third instar, 0.0017 to 0.0077; fourth, 0.0044 to 0.0188, and the fifth, 0.0093 to 0.0462 gram. In most instances, the lowest weights cited for each instar pertain to low-fed (diet X) male nymphs, the highest to well-fed (diet D) female nymphs. The range in net gains, by instars, was: 0.0004 to 0.0012 gram; second, 0.0003 to 0.0020; third, 0.0009 to 0.0050; fourth, 0.0012 to 0.0125, and fifth instar, 0.0023 to 0.0286. For the nymphal stage as a whole, the variation in net gain was 0.0066 to 0.0460 gram.

Even the 14 individuals composing the best-fed series (diet D) displayed a wide range in amount of gain in weight. For the entire growth stage, they multiplied their weights by 107 to 170 times. The eight included males varied from 110 to 141 times, the six females from 109 to 170 times. In terms of per cents, the spread for the males was 10937 to 13974, while that for the females was 10826 to 17011, or an average increase of 13356 per cent from hatching to maturity for the 14 nymphs.

Range in Weights of Adults.—The capacity for variation in the adults is not so extreme as that of the nymphs. The newly transformed adult is decidedly lighter than the full grown, about-to-molt nymph, on account of the loss in solids and fluids suffered during the last molting process. The amount of gain made varies thereafter largely with sex and the bulk of food ingested (Table I). Individuals fed meagerly as nymphs and adults live only a few days at most, feed subnormally even when adequate food is provided, lose weight from day to day and produce no eggs. On the other hand, individuals allowed a more or less adequate quantity of prey in both stages add weight rapidly after the final molt. From Table I it may be seen that medium-fed bugs (diet A) reach their peak weights, i.e., the highest weight or weights reached during adult life, early in the stage, but lose gradually thereafter so that their weight on the final day, or in the last 10 days, falls below that of the first day or first 10-day period. Associated with this pattern is failure to produce eggs or ability to produce but few, and a comparatively brief adulthood. But well-fed adults (diet D) given *Musca* commensurate with their ability to utilize them, attain their peak weights late in life, and generally in the last 10-day period, if not on the last day. Moreover, the females produce a fair number of normal eggs deposited naturally in two rows, persist in oviposition late into life, and live a relatively long time. It may therefore be

stated as a rule that adult *diadema* achieve their peak weights later and later in life as the amount of food ration is increased.

The greatest weight attained by any individual reared in the course of this study was 0.0733 gram, an adult female late in her lifetime.

Weight Pattern of the Nymph.—The developmental curve for medium (diet A) and best-fed (diet D) nymphs (fig. 1, b-e) consists of five similar attenuated S-shaped figures, which correspond to the number of instars and molts. The curve of each instar comprises two phases distinguishable by certain physiological characteristics. The first phase occupies most of the time of the instar, and begins one to two days after exuviation. The new cuticle has been formed and set, the mouth-parts hardened, and the bug resumes feeding. The rate of ingestion is surprisingly high in the first one to several days, but then falls off somewhat gradually until it becomes negligible and probably ceases for one to several hours just previous to the next molt as the body tissues become saturated with food and/or unexcreted waste. Paralleling the changes in rate of feeding, the body weight ascends abruptly for one to three days, after which the rate of acceleration declines with the approach of saturation. Since this aspect of the instar is characterized by heavy feeding and a corresponding growth, it may be designated the *feeding-growing phase.*

The second phase begins some hours to a day or two before the molt, and ends one or two days after the molt with the resumption of feeding. Little if any feeding takes place just before the molt, hence no growth occurs, and some records indicate a slight pre-molt decline in weight. Then follows the shedding of the cuticle, which process is accompanied by evaporation of fluid from the new cuticle while this remains soft and moist, and probably also by partial dessication of the viscera, which stimulates the intensive feeding observed early in the feeding-growing phase. The second phase ends with the hardening of the chitinous parts, including the stylets, and restoration of the ability to feed. Due to cessation of feeding and to exuviation and evaporation, the body weight declines markedly, but the loss sustained in this phase is less than the gain in the feeding-growing phase, with the result that a pronounced net increase in weight accumulates during the succession of instars. The second phase requires one to three days, its duration varying more or less with the several instars and feeding. The actual process of exuviation, however, requires less than an hour, and lasted only 15 minutes in a few observed instances. This aspect of the instar may be termed the *molting phase.*

While the above characteristics apply to all the five instars of *diadema*, they must be qualified with reference to the first instar. The nymph has been observed to refuse food and to gain no weight during the first and even the second day after hatching. Dissections revealed that the stomach contains a whitish granular substance comparable to the nutrient present in the egg during the early embryonic phase. The substance in the gut quite clearly originates in the egg, and apparently serves to nourish the nymph in its first days. Since it ingests nothing while consuming energy in activity, the nymph loses weight until feeding on *Drosophila* commences. This loss, whose amount is

not yet accurately determined, is represented on curves *b* to *e* by a slight decline.

Weight Pattern of the Adult.—The weight picture of the adult may be regarded as composed of three phases (fig. 1, b to g). The first is characterized by a decided loss in weight during the first one or two days following the 5-adult molt. The loss results from exuviation and from evaporation of fluids from the soft new cuticle of the newly-molted adult, these being the same factors that operate in the declines which follow the nymphal molts described above.

The second phase is distinguished in best-fed (diet D) adults by a sharp and pronounced rise in weight extending through the first one to several days of adulthood. This increase generally not only offsets the loss incurred in the molting phase but indicates a reserve that mplements the inception of the third phase. As in nymphal instars one to five, this increase in the second phase results from more or less intensive feeding which appears to be actuated by the presumed dessicated state of the body, a condition growing out of exuviation and the simultaneous loss of surfacial moisture. The adult usually ingests as much food in this as in any other period of comparable length, and if strong enough to feed at all, it does so during this phase.

The third phase of the weight pattern embraces all the rest of the time span of adulthood. Even a quick glance at curves *b* to *g* will show it is characterized by frequent deviations from the horizontal due to the normal intakes and eliminations of materials incident to feeding, defecation, respiration and reproduction. However, these fluctuations are of a minor amount and an irregular nature compared with the pronounced and rhythmical rises and drops of the S-shaped nymphal curves. Moreover, the deviations are more extensive in the females because of their greater capacity or disposition to feed and the larger bulk of the sexual products. But when we take an over-all view of adulthood, the third phase proves to be a somewhat flat horizontal plane, signifying that the losses are fairly well offset by the gains, and suggesting that extreme departures from the horizontal, either upward or downward, are made impossible by the physical and physiological limitations that characterize the species.

Amount of Changes in Weight.—The character of the gains and losses incident to nymphal growth in the molting and feeding-growing phases was described above in general terms. Daily weight records now permit a restatement of certain of these changes in more precise mathematical language. First, I cite records for a series of four male and four female nymphs, reared on the best diet (A), to indicate the percentage of daily increase in the feeding-growing phase of the instar. Only the third, fourth and fifth instars are presented. The numbers express the lowest and the highest, or extreme gains in terms of percents, and the average percents.

On the first day of the third instar, the gains in weight among the eight nymphs were: extremes, 13.0 and 60.8 percent, average 46.0 percent. The corresponding values for the second day: extremes, 25.6 and 65.4, average 45.8; third day, extremes, 15.5 and 28.8, average 18.6. Four of the nymphs continued to gain, adding 5.5 to 12.5 percent

in the one or two days remaining before the molt, while the other four lost 1.6 to 4.1 percent in that period.

Corresponding data for the fourth and fifth instars follow. ***Fourth instar:*** first day, extremes, 1.6 and 61.4, average 26.0; second day, extremes 4.3 and 57.3, average 36.3; third day, extremes 9.6 and 44.6, average 27.5; fourth day, extremes were −0.8 and +36.5, average 11.8. Changes in the remaining one or two days of the instar ranged from +5.5 to −10.3 percent. ***Fifth instar:*** first day, extremes 2.9 and 17.3, average 11.3; second day, extremes 11.7 and 43.6, average 27.8; third day, extremes 10.6 and 36.8, average 21.0; fourth day, extremes 5.9 and 27.2, average 18.2; fifth day, extremes 3.5 and 18.3, average 11.2; sixth day, extremes −2.5 and +12.4, average +3.2; seventh day, extremes −8.2 and +5.0, average +0.44. Changes in the remaining one to three days of the instar average −3.6 percent.

A few comments on the above records are desirable. First, the data for any one day are not strictly comparable among the eight bugs because of the variation in duration of any one instar from one individual to another. Second, the average rate of daily increase in weight is highest early in the instar, and declines thereafter to the end of this growth period. In many cases, the nymphs sustained significant losses in the last one or two days preceding the molt. Besides, were the weights taken hourly or at shorter intervals, instead of daily, every individual would probably be found to suffer such a pre-molt loss in each instar, and, moreover, spread in extreme weights would be considerably reduced. Third, the average increase in the fifth instar falls below that of the previous four, probably because these larger nymphs are relatively inept in capturing the *Drosophila* on account of its small size, and also seem to be "frightened" by the *Musca*. As a consequence, this instar is probably prolonged beyond its natural duration and rarely attains its maximum weight on diets provided.

Next are considered the amounts of loss and gain peculiar to the molting phase of the instar. Three factors were considered as possibly responsible for these changes, defecation, exuviation and evaporation. Defecation was eliminated as a possibility when the use of white blotters in the cages, and inspection of the exuviae, showed that no feces are discharged during the molting phase. The weight of the exuviae, subtracted from the total loss during the phase, yields the approximate amount of loss due to evaporation, largely from the soft moist newly-forming cuticle. The weights cited below were taken from fifth instar nymphs at the time of their transformation to adults, and only the individuals displaying the more extreme losses are included because I consider it probable that only these indicate the actual total decline suffered in the molting phase.

The average loss based on a series of such records was 0.0041 gram. The dry exuviae from 70 males averaged 0.00081 gram, and those of 62 females averaged 0.00094 gram, per bug, the average for both sexes being 0.00087. The exuviae alone therefore account for only about one-fifth, or 21 percent of the total loss sustained in the phase, while the remaining four-fifths, or 79 percent, appear to arise from evaporation of fluids largely in the interval between shedding of the old cuticle and the hardening of the new one. In addition to these post-molt

losses due to exuviation and evaporation, the nymph also loses a noteworthy amount of weight in the one or two pre-molt days when it takes no food. This loss is estimated at one or two percent, so that the sum of all the losses experienced in the molting phase is approximately 14 percent of the total body weight as of the end of the feeding-growing phase of the instar. Moreover, there seems no good reason to doubt that nymphs in the molting phases of the preceding four instars sustain approximately the same percentage of loss, for molting in every instar involves a day or more of interruption in feeding, exuviation and rapid surfacial evaporation. That the loss in weight is in proportion to the size of the molting bug is indicated by the fact that the weights of the whole body and of the exuviae in the successive instars multiply at approximately the same rate. See Rate of Progression, below.

TABLE II

LOSSES IN WEIGHT INCIDENT TO COMPLETE STARVATION

Bug	Days Adult was Fed	Last Weight Before Starvation	Weight of Dead Bug	Days Bug Lived	Total Loss in Percents	Average of Daily Losses in Percents
1	0	.0358 gr.	.0256 gr.	14	28.7	2.31
2	0	.0300	.0232	8	22.7	2.86
3	0	.0238	.0207	5	13.0	2.70
4	14	.0313	.0258	6	17.0	3.27
5	21	.0325	.0268	6	17.5	3.15
6	22	.0277	.0254	4	8.3	2.27
7	23	.0337	.0216	8	35.9	5.76

LOSS OF WEIGHT IN STARVED BUGS

Curiosity as to the rate at which starved bugs lose weight prompted me to utilize a few opportunities to make observations on this point. Table II gives the chief facts obtained from seven adult males. Males numbered 1 to 3 sustained malformations of the stylets in the 5-adult molt, hence took no food as adults, and the losses in weight are from substance derived entirely by nymphal feeding. Bugs 4 to 7 had functional mouthparts and fed 14 to 23 days as adults before food was withheld. Numbers 1 to 3 survived an average of 9 days and suffered an average total loss of 21.5 percent during those days before they succumbed. By comparison, bugs 3 to 6, fed an average of 19 days before food was withheld, survived an average of only 5.3 days while losing an average of 14.3 percent of their weight. Well-fed male number 7 lived only 8 days, yet sustained the relatively great total loss of 35.9 percent.

RATE OF PROGRESSION IN GROWTH

Because the weight of nymphal *diadema* is subject alternately to losses in the molting phase and gains in the feeding-growing phase, the growth of the bug is discontinuous. Then arises the question whether the increase in weight from one instar to the next progresses haphazardly or according to some fixed principle. A definite answer

to this question appears to have been formulated first by Przibram and Megusar from their study of the Egyptian mantid, *Sphodromantis bioculata* Burm. They reported that the nymphal mantid doubled its weight in each instar, thus advancing in a uniform manner to the adult state. Their doubling principle was said by Bodenheimer (1932) to apply also to the preovipositional phase of adulthood in the phasmid, *Carausius morosus* L. Since the work of Przibram and Megusar, published in 1912, several other investigators probed the idea of regular progression in other insects, both Heterometabola and Holometabola. The results are divided with reference to the Przibram principle, some corroborating, others tending to negate it.

My weight studies on *diadema* yielded two bodies of data that pertain to this question, first the weights taken from the living nymphs during their development, and second the weight of exuviae from well-fed

TABLE III

GROWTH QUOTIENTS OF NYMPHS. SUMMARY

Diet	Sex	Nymphs Weighed	AVERAGE AND EXTREME GROWTH QUOTIENTS					
			First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage
X	male	5	2.74 2.2-3.7	2.05 1.4-2.3	2.05 1.8-2.2	2.2 1.5-2.4	2.18 1.5-2.7	43.86 25.2-55.2
X	female	3	2.87 2.6-3.0	2.2 2.0-2.6	2.23 1.9-2.4	2.47 2.2-2.7	2.37 2.2-2.6	78.27 65.5-101.9
A	male	18	3.54 2.6-4.8	2.48 1.6-3.7	2.67 1.9-3.5	2.48 1.9-2.9	2.26 2.0-2.6	119.4 85.9-144.1
A	female	12	3.6 3.0-5.2	2.47 1.7-3.6	2.57 2.0-3.3	2.56 2.1-3.0	2.52 2.1-2.8	149.3 109.2-170.4

nymphs of the five instars (Tables III and IV). Following the practice of previous students, I have adopted the growth quotient as an expressive means of stating the amount of progress made in the succession of instars, a method first employed by Jucci (Bodenheimer, 1932). This quotient is obtained simply, by dividing the final or end weight of the nymph, either in an instar or the whole nymphal stage, by its initial weight in the same stage.

The 38 nymphs concerned in Table III were fed at two rates, on diets X and A. The 38 individual records are totalled as (1) averages and (2) extremes for each instar and for the whole nymphal stage. The quotients for the whole stage are not equal to the sum of the quotients of the five component instars.

Several general facts may be deduced from these data. First, the bugs within any one sex-diet series exhibit a considerable variation in average and extreme growth quotients from instar to instar. Second, the consistently major difference lies between the first instar, on the

one hand and the second to fifth, on the other. Third, conspicuous advances in growth quotients appear as the ration is increased from low (diet X) to medium or near-maximum (diet A). Fourth, excepting the first instar, the rate of increase in the males on diet X departs but little from the doubling principle of Przibram, but departs considerably from it in the females of the same dietary series, and the degree of divergence reaches its maximum in the better-fed males and females on diet A.

This study, therefore, indicates that the growth quotient varies with both sex and quantity of food allowed the experimental bug, increasing from male to female and as the dietary is improved. So far as the intersexual difference is concerned, this may hinge on the normal greater avidity of the female. The study indicates further that ***diadema*** at most merely approximates the doubling principle and does so only when fed at a near-minimum rate (X). When allowed a more nearly adequate quantity of food, the weight increase proceeded at a greater rate that transcends doubling, attaining the maximum of about 2.5

TABLE IV

WEIGHT OF EXUVIAE

Exuviae from Molt Number	Number of Exuviae Weighed	Total Weight of Exuviae in Grams	Average Weight of Single Exuviae	Growth Quotient
1–2	46	0.0012	0.0000261	...
2–3	27	0.0012	0.0000444	1.7
3–4	27	0.0034	0.0001260	2.8
4–5	35	0.0106	0.0003029	2.4
5–adult	30	0.0232	0.0007733	2.6

among female nymphs. That sex and quantity of food are factors regulating the rate of weight increase is indicated most strikingly by the extreme figures for each instar and by the data cited under "nymphal stage" in Table III.

Also the weights of the exuviae from the five instars (Table IV) indicate the nature of the growth rate. Since the exuviae of only well-fed nymphs are admitted here, these data correspond to the weights of the whole bugs given diet A, Table III. Again, excepting the two-three molt, the rate of progression through the instars, as reflected by the exuviae, is fairly uniform and closely approximates the number 2.5, the quotient derived from the weights of the well-fed nymphs cited in Table III.

NOTE

Discussions, summary and references cited for the study of *Sinea* are combined with those pertaining to *Phymata*, and will be found at the end of the previous article on the latter bug.

SEVEN NEW MITES FROM RATS IN PUERTO RICO

IRVING FOX,
School of Tropical Medicine,
San Juan, Puerto Rico

The new species of mites described in this paper were discovered during surveys of the rats of Puerto Rico. These surveys have as their object the classification of arthropods associated with or parasitic upon rats to the end that possible new vectors of endemic typhus fever may be made known to investigators. Types of these new species are in the entomological collection of the Department of Medical Zoology, School of Tropical Medicine, San Juan, Puerto Rico.

Family **Laelaptidae**

Atricholaelaps strandtmanni n. sp.

Figure 2

Female.—Body well provided with long setae, about .70 mm. long (exclusive of capitulum) and about .52 mm. wide. Chelicerae large and prominent the movable arm toothed, the fixed arm with a process. Sternal plate sculptured with three pairs of long setae and two pairs of pores placed as usual for the genus, and as in other species it is preceded by a sclerotized pre-sternal area. Posterior to the sternal plate is a pair of minute plates which may be remnants of the metasternal plates, but the metasternal setae are located some distance posterior to them. Endopodal plates well sclerotized. Genitoventral plate large, removed from the anal plate by about the width of the anal pore, posterior portion broader than the anterior, the border of the latter weakly sclerotized; genital setae long and prominent. Metapodal plates three on a side, two small and one large, the largest being about one-third as wide as it is long. Anal plate triangular with the anal pore closer to the anterior border than it is to the posterior. Paired anal setae at a level slightly anterior to the middle of the anal pore; unpaired anal seta located slightly anterior to the posterior edge of the plate. Posterior portion of the ventrum with many setae which form irregular rows; of particular interest is such a row consisting of about ten setae located between the genitoventral and anal plates and their adjoining areas. Peritreme extending to the middle of coxa I, the inner edge very irregular. Stigmal pore distant from the lateral border of the body. Dorsal plate occupying most of the dorsal surface of the body, with many setae. Chaetotaxy of the legs characteristic of the genus.

Type material.—Female *holotype* from *Rattus* sp. or *Mus M. musculus* collected at Camp O'Reilly, Gurabo, Puerto Rico, during the period April 17 through October 9, 1945.

Remarks.—This new species is similar to *A. megaventralis* Strandtmann in having a dorsal plate which occupies most of the dorsum but differs from the latter in that the anal pore is closer to the anterior

border of the anal plate than it is to the posterior one and in the shape of the largest metapodal plate.

Borinquolaelaps setulus n. sp.

Figure 5

Female.—Body sparsely provided with setae, about .38 mm. long (exclusive of capitulum) and about .22 mm. wide. Sternal plate not sculptured, longer than wide with ear-like extensions anteriorly, with the usual number of setae and pores, the former being rather weak. Metasternal plates large but weakly sclerotized the setae located on the outside borders. Endopodal plates very much reduced. Genital plate weakly sclerotized, slightly rotund posteriorly. Ventro-anal plate large, closely approaching the genital, shield-shaped, provided with three pairs of setae in addition to those of the anal pore. The areas lateral to the ventral plates and posterior to the legs bear on each side four setae of which the most posterior is curved and robust, longer than the others. Metapodal plates not discernible. Peritreme long and narrow extending to beyond the anterior margin of Coxa I. Dorsal plate not occupying the entire dorsal surface, sparsely provided with short setae anteriorly, posteriorly with two pairs of much longer curved ones. Chaetotaxy of the legs characteristic of the genus.

Type material.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, November 4, 1946.

Remarks.—This new species is similar to *B. dentatus* Fox from which it differs particularly in the shape of the ventro-anal plate.

Blattiosocius keegani n. sp.

Figures 6 and 7

Female.—Body oval, about .44 mm. long (exclusive of capitulum) and about .22 mm. wide. Chelicerae large (fig. 6), fixed arm without a process bearing three teeth, much shorter than the movable arm which is armed with one tooth. Sternal plate as in fig. 7, its setae weak. Metasternal plates absent, but the setae present. Entopodal plates absent. Genital plate with the anterior border rounded, the posterior one truncate; genital setae located at the lateral edges. Ventro-anal plate large, shield-shaped, bearing three pairs of setae in addition to those of the anal pore. Paired anal setae level with the posterior border of the anal pore; unpaired anal seta of the same size as the paired ones located near the posterior border of the plate. Metapodal plates absent. Flanking the genital and ventro-anal plates are four setae on a side of which the most posterior are large and curved. Peritreme very short reaching to about the middle of Coxa III, the stigma distant from the lateral border of the body. Dorsal plate not covering the entire dorsal surface, armed with long setae. Legs armed with weak setae.

Type material.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, April 15, 1947, and female *paratype* from same host and locality, June 25, 1946.

Remarks.—This new species is similar to *B. triodons* Keegan from which it differs in details of the shape of the ventral plates and in the armature of the chelicerae.

Family **Ascaidae**

Asca muricata n. sp.

Figure 1

Female.—Body provided with setae of moderate length, about .32 mm. long (exclusive of capitulum) and about .17 mm. wide. Chelicerae large, toothed. Sternal plate very weakly sclerotized, its setae short. Anterior pair of sternal setae inserted near the anterior border far above the pores; most posterior pair of sternal setae located far below the posterior pores. Metasternal setae inconspicuous, their plates apparently absent. Endopodal plates much reduced or absent. Genital plate weakly sclerotized, the setae short. Between the genital plate and the ventro-anal plate are six setae arranged in two rows, one consisting of four setae and the other of two. Ventro-anal plate broader than long, armed with several setae in addition to the anal ones. Metapodal plates relatively large, more or less boat-shaped. Peritreme long reaching to beyond the anterior border of Coxa I, stigma distant from the lateral border of the body. Dorsal plate divided, as is characteristic of the genus, with short setae; tubercles on the posterior border very much reduced but their setae long. Legs armed with weak setae.

Type material.—Female *holotype* from *Rattus norvegicus* collected at San Juan (San Juan proper), Puerto Rico, May 16, 1947.

Remarks.—This new species is distinguished from the other members of the genus by the extreme reduction in size of the tubercles on the posterior border of the notogaster.

Family **Liroaspidae**

Liroaspis armatus n. sp.

Figure 4

Female.—Body abundantly provided with short plumose setae located on small circular plates, about .53 mm. long (exclusive of capitulum) and .37 mm. wide. Chelicerae large, the fixed arm with a large tooth, the movable arm serrate. Sternal area characteristic of the genus with two pairs of setae located on very faint more or less oval sternal plates I and II and a row of four setae on a crescent-shaped plate (sternal plates III and IV) in front of the genital fissure. Genitoventral plate large reaching to the posterior borders of Coxae IV, armed with three pairs of setae, the fourth pair, usually present, is not discernible. Between the genitoventral and the anal plate are a number of short setae located on conspicuous circular plates. Anal plate more or less circular oddly sculptured with seven pairs of setae in addition to

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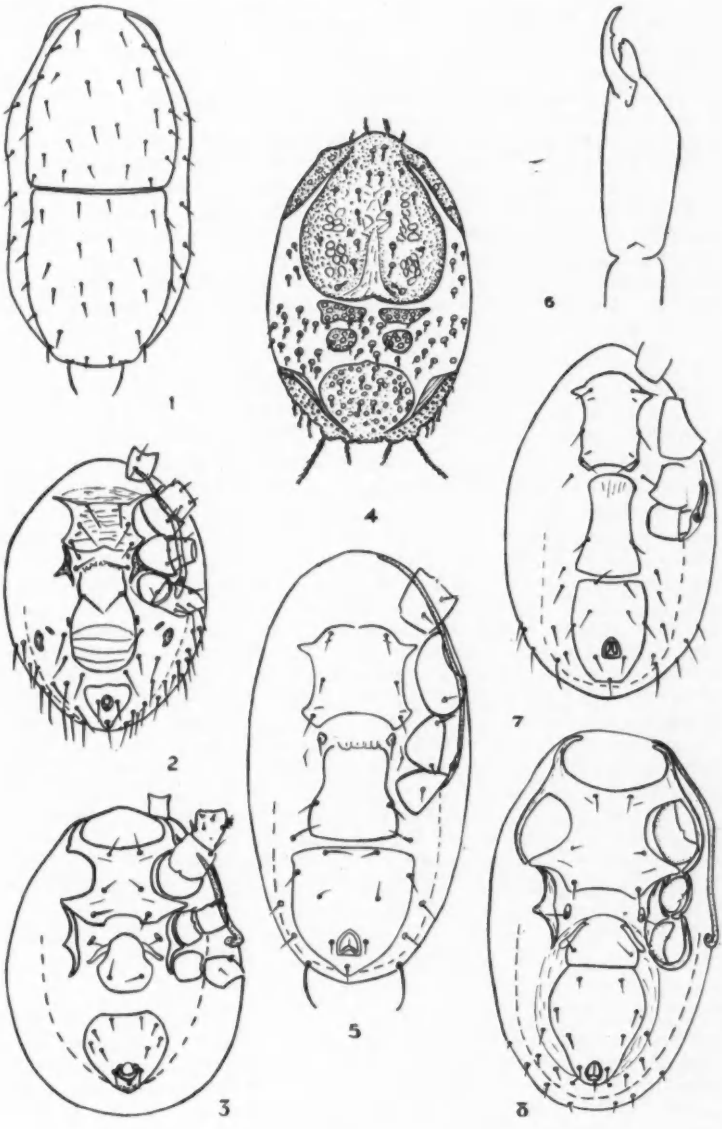
EXPLANATION OF PLATE I

1. *Asca muricata* n. sp., female, dorsum. 2. *Atricholaelaps strandtmanni* n. sp., female, ventral plates. 3. *Macrocheles cardiatus* n. sp., female, ventral plates. 4. *Liroaspis armatus* n. sp., female, dorsum. 5. *Borinquolaelaps setulus* n. sp., female, ventral plates. 6. *Blattiosocius keegani* n. sp., female, chelicera. 7. *Blattiosocius keegani* n. sp., female, ventral plates. 8. *Macrocheles lyratus* n. sp., female, ventral plates.


1
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the anal ones. Paired anal setae located below the middle of the pore, plumose as is the unpaired seta. Posterior border of the body with a large sculptured plate which on the ventral surface bears a pair of plumose setae; dorsally the plate bears two tubercles on a side, not so large as in other species, each of which bears a long plumose seta. Dorsum as shown in fig. 4, the plates oddly sculptured. Peritremes wide, reaching to the middle of Coxa I, the stigma distant from the lateral border of the body. Legs armed with many plumose setae.

Type material.—Female *holotype* from *Rattus rattus* (*alexandrinus?*) collected at San Juan (Santurce), Puerto Rico, June 11, 1947; female *paratype* from *Rattus norvegicus* collected at San Juan (Puerta de Tierra), Puerto Rico, April 9, 1947.

Remarks.—This new species is similar to *L. togatus* (Koch), but differs in the structure of the tuberculated plate which terminates the abdomen.

Family **Macrochelidae**

Macrocheles cardiatus n. sp.

Figure 3

Female.—Body sparsely provided with setae, about .81 mm. long (exclusive of capitulum) and about .62 mm. wide. Chelicerae large and toothed. Sternal plate anteriorly with large lateral expansions, setae and pores placed as usual. Metasternal plates small. Endopodal plates large. Genital plate small, posteriorly truncate anteriorly with wing-like expansions, the genital setae about as large as the sternal ones. Metapodal plates not discernible. Ventro-anal plate more or less heart-shaped, well separated from the genital plate, provided with four pairs of short setae in addition to the anal ones. Anal pore posteriorly removed by a sclerotized area which does not reach to its anterior border. Basal portion of the peritreme forming a hook and extending beyond the lateral border of the body, anteriorly reaching to the middle of Coxa II. Dorsal plate not covering the entire dorsum, allowing large margins laterally and posteriorly. Legs provided with large setae, some of which are plumose.

Type material.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, January 3, 1947.

Remarks.—This new species is similar to *M. fonsecai* Fox from which it may be distinguished by the differently shaped ventro-anal plate which is distant from the genital one.

Macrocheles lyratus n. sp.

Figure 8

Female.—Body provided with short setae, about .68 mm. long (exclusive of chelicerae) and .43 mm. wide. Chelicerae large, toothed. Sternal plate large with broad lateral expansions anteriorly from which arise the large curved endopodal plates II which encircle Coxae II; sternal setae short placed as usual. Endopodal plates III and IV strongly sclerotized encircling Coxae III and IV. Metasternal plates well sclerotized their setae located at the posterior ends. Genital

plate truncate posteriorly its setae short. Ventro-anal plate inverted lyre-shaped, contiguous to the genital plate, provided with three pairs of setae in addition to the anal ones. Paired anal setae located slightly above the middle of the pore and somewhat distant from the latter. Flanking the posterior portion of the ventroanal plate are four setae on each side. Metapodal plates not discernible. Peritreme basally extending beyond the lateral border of the body, anteriorly reaching to beyond Coxa I. Dorsal plate not covering the whole dorsal surface, provided with short broad setae.

Type material.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, May 2, 1947.

Remarks.—This new species is similar to *M. alatus* Fox from which it differs in being much larger in size and in having the ventro-anal plate contiguous to the genital one.

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NATURE AND PREVENTION OF PLANT DISEASES, by K. STARR CHESTER, Second Edition, xi+525 pages, 224 figures, 1947. The Blakiston Company, Philadelphia and Toronto. Price $5.00.

The purpose of this book, according to the preface, is to meet the needs of students whose training in plant pathology is to be limited to a semester or to a year. For them the author offers a survey of "the leading diseases of the major crops grown extensively in the United States, . . .the recognition of these diseases, . . . and the latest generally approved methods of their control." He also includes a survey of the underlying principles of plant pathology.

In the first nine chapters fungous diseases are treated. Separate chapters cover rusts, smuts, fleshy fungi and mycorrhizae, ascomycetes, imperfect fungi, physomycetes and related fungi, and damping off and related troubles. Chapter 10 covers bacterial diseases, chapter 11 viruses, and chapter 12 diseases caused by parasitic seed plants and algae. Diseases caused by nematodes are considered in chapter 13 and physiogenic diseases in chapter 14. The remainder of the book is devoted to principles and methods of control. Chapter 15 includes methods of study, chapter 16 the relations of environment to parasitic diseases and chapter 17 the etiology and epiphytology of disease. Chapter 18 considers the control of diseases by regulation, such as quarantine, chapter 19 control by inducing resistance, and chapter 20 control by cultural methods. Each chapter is concluded with a bibliography and the book ends with a glossary and an index.

The role of insects as vectors of plant diseases is considered and the methods of control necessarily overlap those which are familiar to entomologists, although the writer adheres closely to the major purpose of his book. Because of the close relationship of the two fields, economic entomologists should find the book a valuable source of information. The numerous half-tone illustrations are not of high quality, but the reviewer has noted none which fail to serve their purpose well. In general the book is well organized, well written and altogether excellent treatment of the subject.—A. W. L.

THE SPECIES OF LAC INSECT STUDIED BY COMSTOCK

S. MAHDIHASSAN,
Osmania University, Hyderabad, Deccan

With regard to the origin of the material which Comstock (1) studied in 1880 he says, "From a quantity of commercial stick lac purchased in New York I obtained specimens of an insect which I have no doubt is the *Coccus lacca* of authors." Since the lac insects are cultivated like the silk worm in China or in Italy more information is necessary than the mere record of the locality and of the host plant. For example on *Shorea talura* in the Mysore State the insect, *Lakshadia mysorensis*, is cultivated while a few years ago the same tree bore an encrustation of *Lakshadia communis* which differs from the other in several respects. To those who still believe that there is only one species of lac the question does not arise as to the source of the material Comstock studied. However, it will be shown that a few authors confirm Comstock's findings because they also studied the same species while others do not as they were dealing with an entirely different insect.

The lac insect has been valued for two of its products, in recent times for its resin, better known as shellac, and formerly on account of its red dye for silk and wool. Exactly a hundred years previous to Comstock, in 1780, Swagerman (2) came to the conclusion that there are at least "three sorts of lac and of them all that coming from Siam was the best." That was the age when the dye alone was of value and naturally Swagerman could have only meant that weight to weight stick lac from Siam gave the best yield of lac dye. This is true of *Lakshadia chinensis* material which is cultivated from Assam to Tonkin, including Burma and Siam. Even up to 1880 lac dye was greatly in demand and stick lac was exported for dyeing which makes it probable that Comstock bought specimens belonging to *L. chinensis*. In several Museums of Natural History, on the Continent, the only specimens of lac deposited by the contemporaries of Comstock belong to the same insect. I have had the occasion to examine the specimen of stick lac kept in a show case in the Museum at Prague which belonged to *L. chinensis*, as also did Museum specimens at Vienna, Berlin and Copenhagen.

As late as 1901 Newstead (3) illustrated stick lac belonging to the same species. On Plate I, fig. 1, he has several photographs of stick lac, the largest specimen being placed topmost and free from any twig. Now it is mostly, if not invariably, enrustations of *L. chinensis* that can be easily detached from their twigs. But for this property Newstead's photograph is not typical of this material, which I was, however, able to verify as belonging to *L. chinensis* from some type material kindly sent to me by Prof. Newstead. The lac industry in Indochina depends entirely on *L. chinensis* and Hautefuille (4) (1924) says with regard to stick lac there, "In Tonkin the product as a whole is larger, more voluminous, thicker and more easily detached from the twig to which it is attached (p. 19)." These properties can be illustrated by a photograph, as fig. 1

here is expected to do. Moreover, as early as 1760, Ledermuller (5) had already discovered the property of stick lac being detached from its associated stick which he tried to illustrate. His figure is reproduced as fig. 2 here. It has been turned upside down for the basal portion of an encrustation is more uniform in outline and the encrustation is thinner than on the upper portion. I further imagine the encrustation was larger and has been broken so that only a portion of it is represented.

Most lac insects feed on twigs .3–.8 cm. in diameter but *L. chinensis* can attack thick stems, 2–4 cm. in diameter. Ledermuller's specimen,

FIG. 1. *Lakshadia chinensis*, encrustations on *Cajanus indicus*, Assam, monsoon season. Twig was easily removed. "B" shows a thicker edge on the more convex, Cx, than on its concave, Ce, side. The hollow central channel shows the thickness of the twig. "A" shows the other surface of the same encrustation. Magnification, 11 : 10.

fig. 2, would bear testimony to this fact. In fig. 1 the central hollow grove is also thick for the other species of lac insects. Its width indicates the diameter of the twig that bore the encrustation.

On a horizontal twig the insects settle only on the lower surface, facing the earth and along the sides of the stem. In fig. 1 the raised portions of encrustations show the two rows of insects that had settled on either side of the horizontal twig. When the horizontal twig is

FIG. 2.

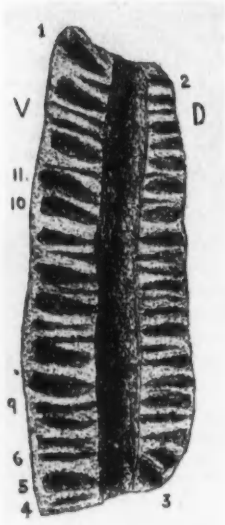

FIG. 3.

FIG. 2. Encrustation of *Lakshadia chinensis*, detached from a thick stem; the raised edge to the left shows a gradual decline in thickness and indicates its position as it grew in nature. It is Ledermuller's picture, turned upside down. Natural size.

FIG. 3. Longitudinal section, natural size, of an encrustation of *Lakshadia chinensis* that had enveloped a twig. It was nearly but not exactly vertical, the side inclined towards the earth is ventral, V, where the row of cells are larger, than cells on the opposite or dorsal side, D. From Comstock.

FIG. 4. *Lakshadia chinensis*, an elongated insect, columnar in shape with a finger-like thin anal tubercle; compare cell No. 1, Fig. 5. From v. Gernet.

curved the convex side shows a better growth of insects forming a marginal encrustation as along the edge Cx, in fig. 1B and a relatively poorer edge along the concave side, Ce, fig. 1B. Fig. 1B shows the encrustation facing the earth and seen from above a horizontal twig; fig. 1A is the same object as in fig. 1B seen reversed and at its best.

On a vertical twig the insects settle all around it and the encrustation is a cylindrical tube enveloping the twig. Comstock gives a longitudinal section of such an encrustation, showing its natural size in his fig. 2, Plate XIX. It is offered here as fig. 3. As far as I know it is the very

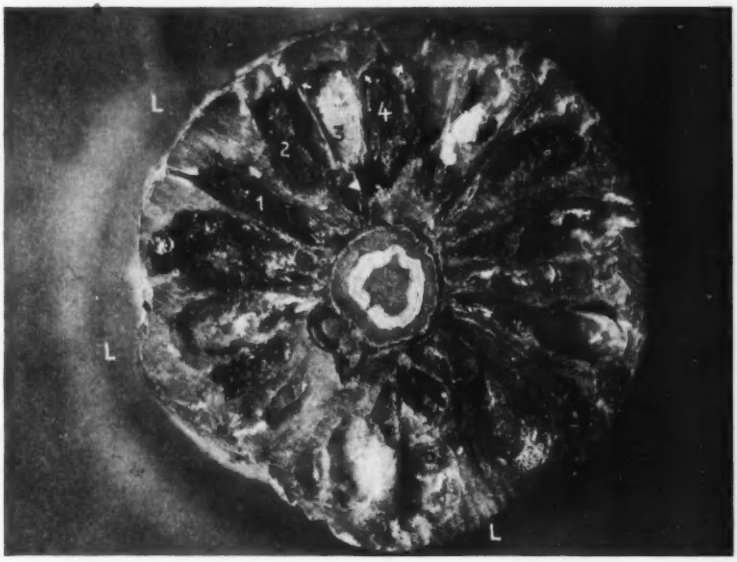

FIG. 5. Cross-section of fresh stick lac of *Lakshadia chinensis*, Nowgong, Assam, with cells of indistinct shape. Cells Nos. 2–4 are almost rectangular in shape with broad upper surface indicated with arrows in Cells 3 and 4. In portions lac secretion is rich, L. Magnification 37 : 10.

first section of lac seen longitudinally. It reveals a honey-comb like structure with cells which were occupied by living insects. But no vertical twig is ideal, the side more inclined towards the earth is to be understood as its ventral side and the opposite as its dorsal side. Fig. 3 shows the encrustation having a better row of cells on the Ventral, V, side than on the Dorsal, D, side. In fig. 3 cell No. 1 for example is topmost on the ventral side and is far bigger than the corresponding cell No. 2 on the dorsal side of the encrustation. The same applies to the row of cells Nos. 4, 10 and 11, which are bigger than the long row of cells on the dorsal side from No. 2 to No. 3.

In all encrustations basal cells are larger than those on the top, e. g., No. 3 in fig. 3 is larger than No. 2. This point is also evident on a careful examination of the picture Ledermuller offers where the raised edge of the encrustation is not uniform throughout its length. It has to be turned upside down and to be shown as it is reproduced here as fig. 2 as already mentioned. In fig. 2 the thick ridge to the left gradually thins towards the top.

Comstock shows fig. 3 free from the twig while later on Green (6) (1922) has a similar picture from material belonging to *L. nagoliensis* but with

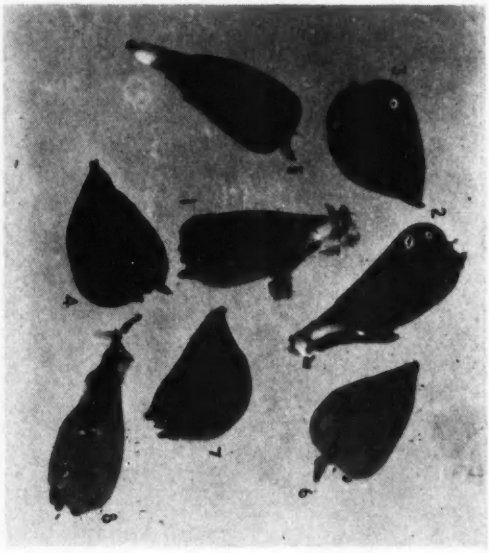

FIG. 6. *Lakshadia chinensis* after treatment with cold caustic solution. Insects Nos. 1, 2 and 8 with pads of hard wax on their ventral surface. Insects Nos. 1, 2, 3 and 4, where these figures stand, show sharp corners of the body which has a broad dorsal surface. Insect No. 8 does not show this feature and may be contrasted.

the stick still present. Any one who handles encrustations from these two sources will at once notice how easy it is to remove the stick from *L. chinensis* and how difficult from *L. nagoliensis* lac.

It had been pointed out that cells on the ventral surface, V, fig. 3, are larger. Cell No. 4 and cells Nos. 6–9 are almost linear in their representation. V. Gernet (7) has previously illustrated such a columnar body of a lac insect as thick at the base as it is at the top and his picture is reproduced as fig. 4. Besides its anal tubercle is thin, finger-like and could not be more conspicuous; in no other insect such is the

case with the anal tubercle. Fig. 5 is a cross section of fresh stick lac and there insect No. 1 is likewise as thick at the base as at the top and has a thin, long anal tubercle.

Elongated cells as seen in fig. 4 were examined carefully. Eggs were found fully formed. From some larvae had also swarmed so that they represent individuals that had become mothers and are thus fully developed. In fig. 3 Comstock shows cells Nos. 10 and 11 rectangular in shape. These are not idealized representations. Fig. 5 shows insect No. 2 almost rectangular and cells Nos. 3 and 4 are approaching it. The white arrows indicate in cells Nos. 3 and 4 the broad and straight shoulders, as it were, of these insects. In fig. 3 Comstock further indicates cells Nos. 10 and 11 and others a little to the interior of the marginal line. In fig. 5 portions where lac secretion is thick are marked, L, and this feature shows the insects well covered with a thick secretion of lac; insects Nos. 1 to 4 are all beneath the outline of the circumference.

Fig. 5 shows the shape of the cells as very irregular. This is a photograph and hence represents typical features of the encrustation belonging to *L. chinensis*. Fig. 6 shows the individual lac insects of this species. Insects Nos. 1, 2 and 8 have thick pads of ventral hard wax which has been previously illustrated (8). In this species the glutinous portion of ventral wax is very large and such pad like appearance is peculiar to *L. chinensis*. Insects Nos. 1, 2, 3 and 4 where these figures stand show a broad and flat surface of the body with the anal tubercle. In no other lac insect is this the case; this confirms the shape of cells 10 and 11 in fig. 3 from Comstock. Fig. 5, cell No. 5, shows one side as a straight line and the other as a semicircle. In fig. 6 insect No. 7 has the identical shape and so is almost insect No. 4. In fig. 6, the anal tubercles of insects Nos. 5 and 6 are not so thin as in insect No. 1 of fig. 5 but the former compare well with the previous illustration given by Tozzetti who also represents the same species in his fig. 12 as reproduced by Gascard (9).

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NOTES ON THE PHLEBOTOMUS OF PANAMA
(Diptera, Psychodidae)[1]

I. The Subgenus Brumptomyia Franca and Parrot 1921

G. B. FAIRCHILD[2] AND MARSHALL HERTIG[3]

In 1943 one of us (Fairchild 1943) listed the *Phlebotomus* species then known from Panama, four described species and two other undetermined species which appeared to be new. In the subsequent four years we have made a special effort to collect these insects, using more effective techniques, and have amassed an estimated 10,000 specimens representing about 30 species. We hope to report on this material in a series of papers, of which this is the first.

The terminology of the structures useful in the taxonomy of *Phlebotomus* has evolved more or less independently, and the homologies with structures in other Diptera and other orders of insects remain incompletely worked out. We have chosen to use, with slight modification, the terminology of Christophers and Barraud (1926) and Tonnoir (1935), because we feel it to be the simplest, and because there seems to be no general agreement as to terminology among students of Diptera. We give below the terms to be used in this and subsequent papers, with some of their equivalents.

The *ascoids* or geniculate spines are apparently hollow spine-like structures of presummed sensory function found in pairs on all but the last few flagellar segments of the antennae; their shape and size are often of considerable taxonomic importance. The *cibarium*, buccal cavity, buccopharynx or anterior pharynx lies within the clypeus. It is a flat rectangular box-like structure usually bearing vertical and horizontal teeth on the proximal margin of its ventral side. These teeth are generally absent in the male, but their number and arrangement offer good characters in the female. There is also an arched ridge-like thickening of the ventral surface, the *chitinous arch* which seems to be the attachment of the salivary muscle. The chitinous arch is sometimes not visible centrally, and its degree of development and position offer good taxonomic characters. This structure has been neglected as a character of taxonomic importance, Hertig (1938) having first called attention to its utility. The *pigmented area* often seen just distal to the cibarial teeth, is on the dorsal surface of the cibarium and is the place of attachment for the posterior clypeal muscles according to Theodor (1932). The term "cibarium" was suggested to us by Dr. C. D. Michener as being more exact and concise than its more generally found equivalents. The *pharynx* or posterior pharynx lies within the head capsule. It appears to be longitudinally folded in somewhat the manner of a

[1]This work was initiated under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and development and the Gorgas Memorial Laboratory.

[2]Medical Entomologist, Gorgas Memorial Laboratory, Panama.

[3]Major, Sanitary Corps, Army of the United States.

child's paper dart, and is triangular or three-winged in cross-section. It bears spines, teeth or ridges on its posterior end which are often of considerable taxonomic value.

The male *genitalia*, terminalia or hypopygia, are of paramount importance in the classification of the group. As is now well known, the genitalia are rotated through 180° soon after eclosion, so that the morphologically ventral parts become dorsal and vice versa. To avoid confusion, we will describe the parts as they appear on the insect. The most dorsal structures are a pair of two-segmented appendages, called the upper claspers or superior gonapophyses. The basal segment is the *coxite*, basal segment of upper gonapophyses, basistyle, side piece or gonostipes. It is simple or bears spines, modified setae or tufts of various sorts. The *style* is the terminal segment, dististyle or clasper, and bears from one to five or more strong spines. The *parameres*, intermediate appendages, median gonapophyses or median claspers, are situated below and at the base of the coxites. They may be simple, forked or branched and with or without spines, tufts of hairs or modified setae in various situations upon them. Between the parameres lies the *aedeagus*, intromittent organ, penis sheath, phallosome, mesosome or gubernaculum. It is a heavily sclerotized, more or less triangular structure, seemingly formed of two partially fused tubes through which pass the *genital filaments*, penis filaments or spicules, which are themselves tubular. Both structures show modifications of taxonomic value. The filaments pass into the abdomen and join in a heavily sclerotized structure known as the *genital pump*, or pompetta, which is believed to act as a pump to force the sperm through the genital filaments. Attached close to the base of the genitalia ventrally are two unsegmented appendages, the *lateral lobes*, lower claspers or inferior gonapophyses. They are usually at least half the length of the coxites, and may be much longer, slender or inflated, and occasionally with spines or modified setae at their tips. Below and between the lateral lobes lie the *cerci*, anal lobes, proctigers, submedian lamellae or membranous processes. They seem homologous with the female cerci, and indeed in some species where those of the female are of unusual shape, those of the male also have the same shape. They are generally rather uniform throughout the group, and are often omitted from figures and descriptions, though in some cases they are useful in associating the sexes.

Students of *Phlebotomus* have used for many years Greek letters to indicate certain parts of veins whose relative lengths are of taxonomic importance. Tonnoir (1935) established the homologies of these veins, but realized the convenience of the use of Greek letters and continued to employ them. Alexander (1944) condemned their use under the impression that they constituted new names for the veins. In reality the Greek letters stand only for certain definite segments of veins whose measurements projected onto a line tangent to the costa are used in calculating certain proportions believed to be of taxonomic value. Since their use is a great convenience and does not conflict with the established nomenclature of the veins, we shall continue to use them. *Alpha* corresponds to vein R_2 from its junction with R_3, to the costa. *Beta* corresponds to the segment of R from the junction of R_2 and R_3

to its junction with R_4. *Gamma* corresponds to the section of R from the forking of R_4 to the junction of R_5. *Delta* is the section of R_1 which overlaps the junction of R_2 and R_3. R_1 occasionally fails to reach or just reaches the junction of R_2 and R_3, in which cases *Delta* is negative or zero. In our experience, the venational characters so extensively used by some previous workers have proven of rather limited value. With certain exceptions, notably the length of *Delta* relative to *Alpha*, they are of little help in separating closely allied species or in associating the sexes of the same species, and are not to be relied upon in the absence of other supporting characters.

The detailed measurements so often included in descriptions we find unnecessary. If the species shows good structural characters the measurements are largely superfluous; if it does not, the measurements are hardly to be relied upon to characterize it. We have therefore confined ourselves to the following measurements: total wing length, alpha, beta, gamma, delta, third antennal segment, palpal segments, head length, clypeal length, proboscis and vertical eye length. In some cases other measurements have been included where the structure concerned is particularly striking.

In measuring the palpi, we have combined the first and second segments, as the suture between them is oblique, often not distinct, and the first segment varies little in length. The so-called palpal formula, in which the segments are listed in order of increasing length, we have abandoned as useless. In many species two or more segments may be subequal, but varying sufficiently individually to yield different palpal formulas for different individuals of the same species. Conversely, quite distinct species with palpi of markedly different lengths may have the same palpal formula. Palpal measurements are useful in associating sexes, but tend to be a group character, several closely related species sharing the same measurements.

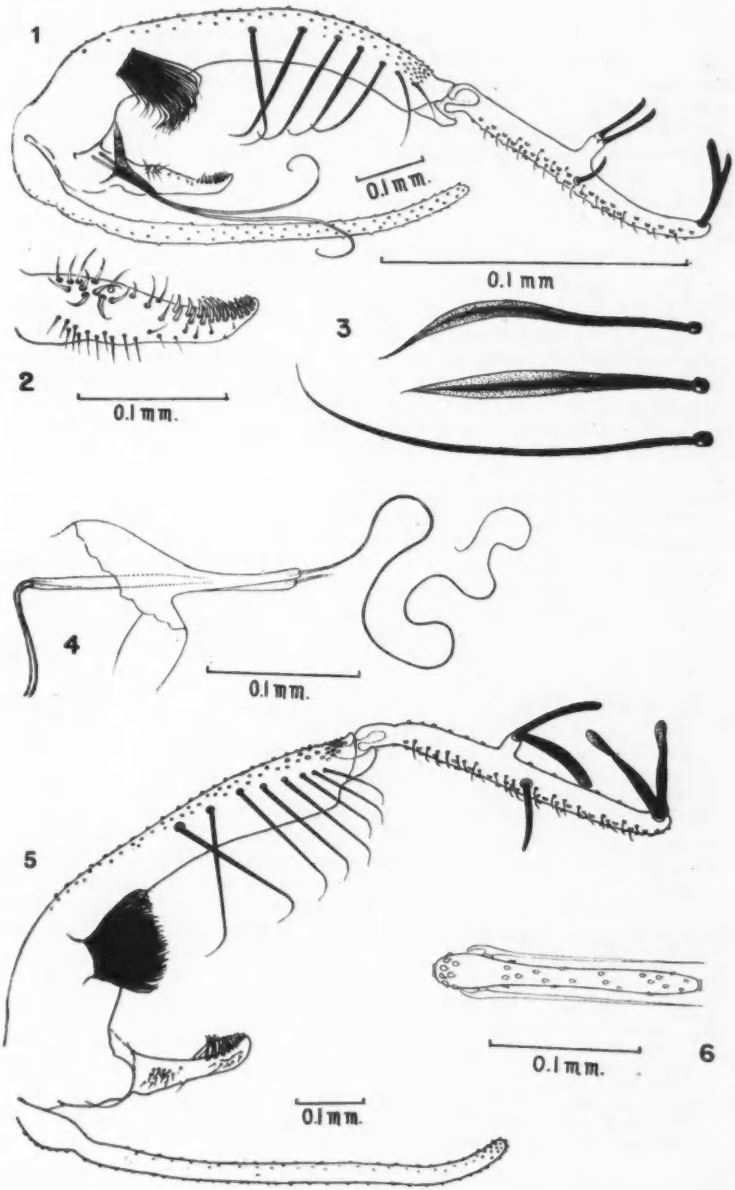
Subgenus **Brumptomyia** Franca and Parrot

1921, Arch. Inst. Pasteur de l'Afrique du Nord, 1, (3), pp. 280, 281, 283, fig. 4 (with *Ph. brumpti* Larr. and *Ph. vexator* Coq.). Dyar, 1929, Am. J. Hygiene, 10, (1), p. 112. (Subgenotype *P. brumpti* Larrousse.) Mangabeira, 1942, Mem. Inst. Oswaldo Cruz, 37, (2), pp. 208–210. Mangabeira and Galindo, 1944, Am. J. Hygiene, 40, pp. 189–190.

Mangabeira and Galindo (l. c.) have redefined the group and include ten neotropical species. Three species, *travassosi*, *avellari* and *guimaraesi* have been reared, and the morphology of the early stages and females described (Coutinho and Barreto 1941; Mangabeira 1942). *P. spinosipes* Floch and Abonnenc 1943, described from the female, has all the characters of the subgenus and could be placed here without hesitation were it not for the peculiar peg-like spines on the hind femora. These are reminiscent of the spines found on the hind femora of *P.*

EXPLANATION OF PLATE I

FIG. 1, *Phlebotomus hamatus*, internal aspect of genitalia, side view. FIG. 2, internal aspect of paramere of *P. hamatus*. FIG. 3, *P. galindoi*, spines of basal tuft. FIG. 4, aedeagus and genital filaments of *P. galindoi*. FIG. 5, *P. galindoi*, genitalia. FIG. 6, eighth flagellar segment of antenna of *P. galindoi*, showing ascoids.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fischeri and related species, on the basis of which Costa Lima erected the subgenus *Pintomyia*. However, the spines on *spinosipes* are peg-like, not sharply pointed as in *fischeri* and allied forms. In both cases they seem but modifications of the long setae usually found in the same situation.

The three species occurring in Panama are apparently quite rare, and we have taken no females referable to *Brumptomyia*. We have added a key to the males of the known species of the subgenus. The females are so similar that in most cases they are practically impossible to identify with certainty.

Phlebotomus (Brumptomyia) hamatus sp. nov.

Figs. 1 and 2

This species is separated from *P. travasossi* Mang. 1942, its nearest relative in the subgenus *Brumptomyia*, by the differently shaped parameres, the greater number and development of the distal spines on the inner aspect of the coxite, the less dense basal tuft borne on a raspberry-like tubercle, and the shorter and less attenuated genital filaments. The ascoids appear to reach almost to the distal ends of their respective segments, and to have a short proximal prolongation, as figured for *travassosi* by Floch and Abonnenc (1942). The name is from Latin *hamatus*—bearing hooks.

The measurements of two of the three specimens at hand are given below in micra. The third specimen is much shrunken and accurate measurement is impossible.

Slide 112. Holotype. Third antennal segment, 384. Palpal segments: 1+2, 132; 3, 128; 4, 92; 5, 220. Wing: total length 2160; *Alpha*, 630; *Beta*, 234; *Gamma*, 342; *Delta*, 90. Head measurements: vertex to fronto-clypeal suture, 300; clypeus, 100; proboscis, 204; vertical eye length, 268.

Slide 222. Paratype. Third antennal segment, 340. Palpal segments: 1+2, 120; 3, 128; 4, 88; 5, 256. Wing not measurable. Head measurements: vertex to fronto-clypeal suture, 244; clypeus, 100; proboscis, 204; vertical eye length, 268.

Holotype male, Chilibrillo bat caves near Chilibre, Panama. Dec. 4, 1943. Taken from a crevice in limestone rock near the entrance to the caves. *Paratype* male, Cruces Trail, Madden Dam highway, Canal Zone, May 14, 1944. From between buttressed roots of a large hollow tree containing bats about 200 yards from highway along old Cruces Trail. *Paratype* male, Chorrera, Panama, 9 July 1944. Taken in an animal burrow. Types to be deposited in the Museum of Comparative Zoology, Cambridge, Mass.

Phlebotomus (Brumptomyia) travassosi Mangabeira

1942. Mem. Inst. Oswaldo Cruz, 37, (2), pp. 201–205, figs. 137–142. (♂; Belem, Para, Brasil. In Armadillo burrows.) Op. cit., (3), pp. 375–382, figs. 1–14 (♀, larva, pupa). Floch and Abonnenc, 1945. Inst. Pasteur de la Guyane, Pub. No. 100, pp. 1, 7; Pl. 3 (♀).

Phlebotomus brumpti Floch and Abonnenc, 1942, Inst. Pasteur de la Guyane, Pub. No. 38, pp. 10–14, figs. 5–6. (♂, ♀; ? French Guiana); 1943, Op. cit., Pub. No. 62, p. 8 (♂; in key only).

A single male, La Victoria, Cerro Jefe, 2400 ft. elev. Oct. 4, 1946, Pedro Galindo coll. This specimen was secured from an armadillo burrow. Subsequent trips to the same locality have failed to yield additional material. This species differs from *hamatus* in the much denser basal tuft of the coxite, the more slender and more sparsely haired parameres, the lighter and fewer apical spines on the coxite and in the much longer and finer genital filaments. Measurements of our single specimen show no differences in wing and palpal proportions from *hamatus*.

Phlebotomus (Brumptomyia) galindoi sp. nov.

Figs. 3–6

This species is somewhat larger than the two preceding in nearly all measurements and differs from both in various details of the genitalia, among which may be mentioned the heavy blade-like spines of the basal tuft, the more distal position of the unpaired spine on the style, and the very long genital filaments. Its closest relatives appear to be *P. brumpti* Larr. and *P. avellari* C. L. From the former it differs in the more distal position of the unpaired spine of the style, the more numerous, more flattened spines of the basal tuft, which are borne on a definite tubercle, the more slender parameres, which also lack dense dorsal hairs at their bases, and in the more slender and tubular aedeagus. From *avellari* the present species differs in the more slender parameres, and in the structure of the style and basal tuft.

The measurements of the unique holotype are given below in micra. Third antennal segment, 440: palpal segments: 1+2, 172; 3, 160; 4, 112; 5, 292; wing length, 2, 934; alpha, 828; beta, 342; gamma, 450; delta, 180.

Holotype male, 4 miles north of Boquete, Chiriqui Province, Panama. 4000 ft. elevation, 17 February 1947. Taken sweeping with a net. P. Galindo collector. To be deposited in the M. C. Z.

KEY TO BRUMPTOMYIA MALES

1. Coxite with a prominent basal tuft of hairs on the inner aspect.....2
   Coxite without such a tuft, though with a few small scattered hairs, **cardosoi** B. and C.
2. Basal tuft of very numerous fine hairs implanted in several contiguous straight rows. Parameres finger-like, slender. Spines of style in two groups, two apical and three median.....**travassosi** Mang.
   Basal tuft otherwise.....3
3. Basal tuft implanted on a circular patch or raspberry-shaped tubercle.....4
   Basal tuft diffuse, the hairs well separated and the area of implantation not differentiated.....10
4. Basal tuft of long fine hairs.....5
   Basal tuft of short stout spine-like hairs.....8
5. Spines of style in three distinct groups.....6
   Spines of style in but two distinct groups.....7
6. Spines on distal half of coxite, 6, with an additional single spine well separated from the others and near the middle of the segment. Parameres rather short and stout.....**guimaraesi** B. and C.
   Spines on distal half of coxite, 4, no additional spine. Parameres slender and finger-like.....**cunhai** Mang...

7. Spines on distal half of coxite 4, rather small and slender. Parameres very slender, clubbed. Genital filaments exceedingly long and thread-like, **mangabeirai** B. and C.
   Spines on distal half of coxite, 7, the basal 5 straight, heavy and long. Parameres slipper-shaped. Genital filaments thread-like at their apices, not unusually long..... **hamatus** sp. nov.
8. Spines of style in two groups, 2 apical and 3 median.....9
   Spines of style in three groups, 2 apical, 2 median and 1 slightly distal of the median group. Parameres with dense hairs only apically. Hairs of basal tuft flattened and blade-like, borne on a distinct tubercle..**galindoi** sp. nov.
9. Parameres short and broad, not twice as long as wide. Tuft on base of coxite of short heavy spines..... **avellari** C. L.
   Parameres more slender, finger-shaped, with rather dense hairs dorsally on the basal part. Tuft on base of coxite of more numerous and more slender spine-like hairs..... **brumpti** Larr.
10. Spines of style consisting of 1 apical, 1 subapical, 1 median and 2 basal, the last paired on a tubercle. Parameres slender and finger-like with numerous heavy bristles on the dorsal surface..... **pintoi** C. L.
    Style always with an apical pair of spines.....11
11. Parameres stouter, finger-like. Median spine of style well separated from basal pair..... **nitzulescui** C. L.
    Parameres thickened and spinose basally and with slender apical dorsally directed, finger-like process. Median spine of style at same level as basal pair..... **troglodytes** Lutz

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NOTES ON THE PHLEBOTOMUS OF PANAMA
(Diptera, Psychodidae)

II. Descriptions of Three New Species[1]

G. B. FAIRCHILD[2] and MARSHALL HERTIG[3]

The three species here considered form an apparently closely related group which is set off from the large group of Neotropical species bearing a basal tuft on the coxite by their inflated lateral lobes and the extreme proximal position of the basal spine of the style. Within the group, *vesiciferus* and *vespertilionis* are most similar in respect to the structure of the male genitalia, both having but three spines on the style, while *deleoni* has four. *Vesiciferus* and *deleoni* have identically formed genital filaments, while those of *vespertilionis* are of a different type. In the females which we have associated with these males, the cibaria are of similar type in all, bearing four strong horizontal teeth and what appear to be two strong vertical teeth as well as a variable number of smaller teeth. The pharynges of all are relatively unarmed, having weak finger-like ridges at their proximal ends only. These ridges bear minute spines, visible only at high magnification. The spermathecae of *deleoni* and *vesiciferus* are of a distinct and unusual type, being apparently somewhat like those figured by Addis (1945, J. Parasit., 31, 2, 119–127) for *P. anthophorus*. The spermathecae of *vespertilionis* are less unusual in structure. Addis erected a new subgenus for his *P. anthophorus*, and indeed the peculiar genitalia, spermathecae and cibarium of his species seem to warrant such an action. However, various of the three species here considered share with *anthophorus* the unusual spermathecal structure and the 3-spined style of the genitalia, while the structure of the paramere is paralleled in a number of not apparently otherwise related species.

Phlebotomus vespertilionis sp. nov.

Plate I

Male—Genitalia as figured. The genital pump and filaments are short, the whole structure being but slightly longer than the lateral lobe. The filaments are rather heavy, finely annulated, and about twice as long as the pump. The basal tuft on the coxite shows considerable variation in the number of hairs, the specimen figured having about the maximum number, while others may have as few as half this number. The margin of the coxite below the basal tuft is quite heavily sclerotized and thickened in this as well as the other two species of the group, but this is not shown in the figures due to the difficulty of portraying it beneath the basal tuft. The parameres curve inward in

[1]This work was initiated under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Gorgas Memorial Laboratory.

[2]Medical Entomologist, Gorgas Memorial Laboratory, Panama, R. de P.
[3]Major, Sanitary Corps, Army of the United States.

undistorted mounts as shown in the figure. In more flattened mounts the paramere may appear broader and straighter. The measurements of wings, palpi, etc., of the three species here considered will be found consolidated in Table I.

Female—Spermathecae, cibarium and pharynx as figured. Cerci rather short and blunt. Ascoids (in both sexes) simple, long, nearly attaining distal ends of segments.

Holotype male, Slide 761, Cerro Campana, Panama Province, Panama, 17 Jan., 1947, ±2500 ft. elev. in a shallow cave with bats.

TABLE I

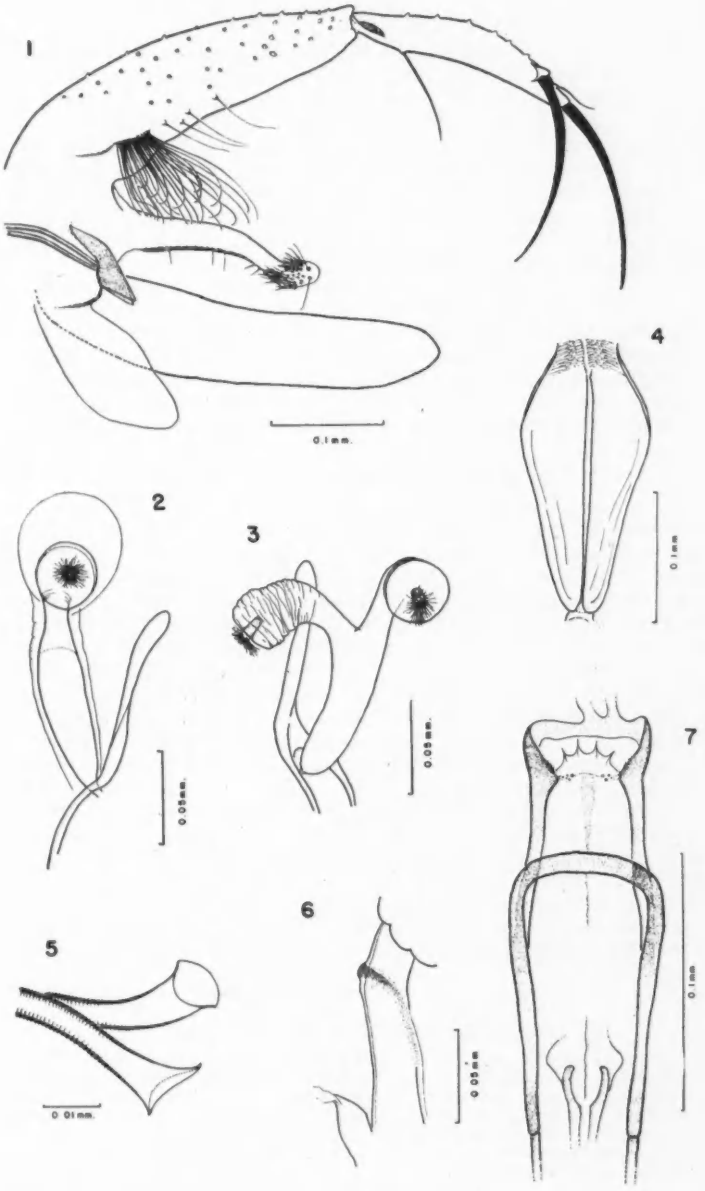
MEASUREMENTS IN MICRA

	P. vesiciferus						*P. vespertilionis*						*P. deleoni*	
	Maximum		Minimum		Mean		Maximum		Minimum		Mean			
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Ant. III.....	388	368	328	260	358	313	428	400	304	324	380	352	368	380
Palpi I+II...	140	160	112	120	132	142	148	180	120	148	136	176	160	192
Palpi III.....	140	160	120	112	132	138	152	160	124	140	140	145	160	172
Palpi IV.....	88	100	72	76	80	84	92	100	72	88	80	93	120	128
Palpi V.....	224	224	200	180	206	200	264	272	204	212	228	236	...	332
Head height..	236	252	212	200	225	236	284	304	236	256	256	278	224	224
Clypeus.....	140	152	92	112	110	134	120	160	100	124	113	140	128	160
Proboscis.....	192	268	148	200	173	238	216	260	172	220	191	248	180	260
Eye height...	176	192	128	144	153	170	212	236	160	180	182	209	148	180
Wing length...	1740	1940	1450	1540	1570	1780	1960	2160	1580	1850	1780	1960	1530	1800
Alpha.....	522	630	396	500	439	550	486	630	396	522	450	552	414	558
Beta.....	216	252	162	180	192	217	288	306	216	252	252	275	198	252
Gamma.....	306	360	216	234	261	293	324	360	252	270	288	302	234	306
Delta.....	270	360	162	270	212	315	216	342	144	252	180	280	126	306

Allotype female, Slide 742, Chorrera, Panama, 1 Dec., 1946, in forest S. E. of town in hollow tree with bats. *Paratypes*, 33♂, 34 ♀ mounted on slides and 539 ♂, 687 ♀ in alcohol, from the following localities: Canal Zone—Juan Mina Sta., Chagres River region; Rio Pequeni, head of Madden Lake; Gatuncillo, Chagres River region; Chiva Chiva road; Cruces Trail, Canal Zone Forest Reserve. Republic of Panama—Panama Province; Pacora; near Arraijan; Chorrera; Cerro Campana; La Victoria, Cerro Jefe, nr. Tocumen; Chilibrillo bat caves, nr. Chilibre; Bejuco. Veraguas Prov.—Santa Fe. Colon Prov.—Puerto Pilon.

EXPLANATION OF PLATE I

Phlebotomus vespertilionis. FIG. 1, male genitalia, inner aspect. FIG 2, spermatheca, drawn from a specimen cleared in phenol without treatment in KOH to show cellular envelope surrounding spermatheca. FIG. 3, spermatheca, drawn in water from a specimen treated with KOH. FIG. 4, female pharynx, balsam mount. FIG. 5, tips of male genital filaments. FIG. 6, female chitinous arch, lateral view, as seen in mount of whole head cleared in phenol. The ventral side is to the left. FIG. 7, female cibarium, stained and mounted specimen, ventral view.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Bocas del Toro Prov.—Changuinola District, United Fruit Company Plantation.

This material was collected on 52 different occasions in every month of the year, from 1944 to 1947. Females were invariably associated with bats, either in hollow trees or in hiding places near the entrances to bat caves. Males were taken fairly frequently between the buttressed roots of large trees in the forest and once beneath boulders in a dry stream bed, as well as in bat roosts. Collecting data seem to show greater abundance from June to December, the rainy season, than from January to June, the dry season, although we have insufficient records to plot the seasonal abundance in detail. Specimens have been taken from sea-level up to about 2500 ft. elevation.

We feel quite confident that this species, if not restricted to bats as its host, at least shows a great preference for these mammals as a source of its blood meal. Only rarely have we failed to find this species present in bat roosts in hollow trees, and the females have never been secured in other situations. Some bat trees have yielded enormous numbers of this species, and this species only, and it is customary to find a high proportion of the females engorged with fresh or partially digested blood.

Phlebotomus vesiciferus sp. nov.

Plate II

Male—Genitalia as figured. The shorter lateral lobes and heavier basal spine of the style are characteristic. The genital pump and filaments are short, but slightly longer than the lateral lobes, and except for their tips, like those of *vespertilionis*. The basal tuft on the coxite shows variation in the number of hairs, but these are generally fewer than in the preceding species. The cerci are relatively longer and somewhat more acutely pointed than in *vespertilionis*. Ascoids in both sexes simple, nearly reaching ends of their respective segments.

Female—Cibarium and spermatheca as figured. Pharynx as in *vespertilionis*. The unusual structure of the spermatheca seems to be due to an enormous asymmetrical inflation of the terminal portion of the body of the spermatheca, which enfolds and overgrows the head, displacing it laterally so that it appears to emerge through an aperture at the side of the body of the spermatheca. From the figures given by Addis (1945) a somewhat similar situation seems to obtain in *P. anthophorus*, though here what we take to be the inflated portion is lobulated, while in our species it is simple and bladder-like. The true appearance is difficult or impossible to discern in permanent mounts, as the exceedingly tenuous walls of the inflated portion invariably

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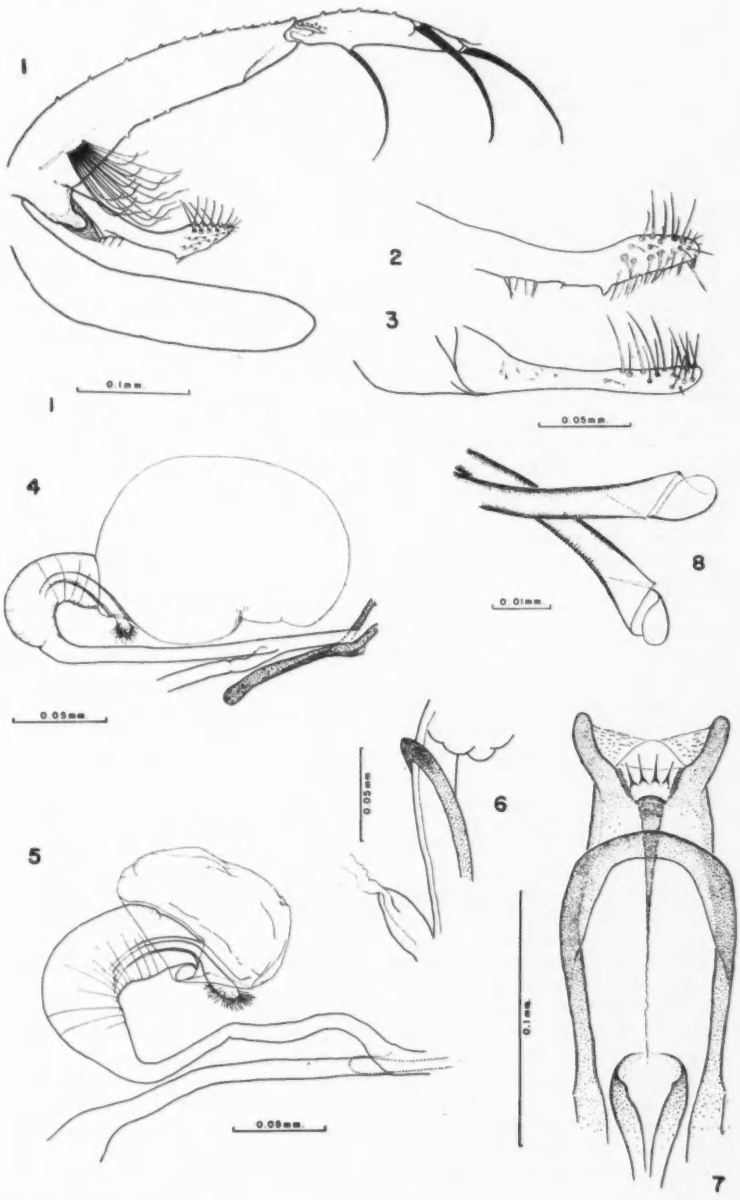
EXPLANATION OF PLATE II

Phlebotomus vesiciferus. FIG. 1, male genitalia, inner aspect. FIGS. 2 and 3, parameres of another example, showing variation of appearance due to orientation, fig. 3 being a dorsal view. FIG. 4, spermatheca, cleared in phenol. FIG. 5, spermatheca in water after KOH treatment. The specimen is somewhat flattened and the bladder collapsed and shrunken. FIG. 6, chitinous arch of female, side view, for comparison with Plate I, fig. 6. FIG. 7, female cibarium, ventral view. Fig. 8, tips of genital filaments.


1
0.1mm
1
2
3
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8
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5
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6
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7

collapse during mounting. Our figures were drawn from a specimen cleared in phenol and from one mounted in water after treatment with KOH. The name is from Latin *vesicus*=a bladder.

Holotype male, Slide No. 680, Cruces Trail, Canal Zone Forest Reserve, 24 Nov., 1946. Taken in a large hollow tree containing bats.

Allotype female—Slide No. 667, Cruces Trail, Canal Zone Forest Reserve, 16 Nov., 1946. Taken in a large hollow tree containing bats.

Paratypes—7 ♂, 5 ♀, mounted on slides and 44 ♂, 1 ♀, in alcohol from the following localities: Cruces Trail, C. Z. Forest Reserve, in hollow tree with bats, 24 Nov., 1946 (1 ♀); Bocas del Toro, Panama, 1 Feb., 1947, in bat caves (1 ♂, 1 ♀); La Victoria, Cerro Jefe, near Tocumen, Panama, ±2500 ft. elev., 23 Jan., 1947, in animal burrows (44 ♂, 1 ♀) and in rock crevices (1 ♀); Cerro Campana, Panama, ±2500 ft., 18 Jan., 1947, in hollow tree with opossum (1 ♀); Changuinola District, United Fruit Co. Plantations, Bocas del Toro Province, Panama, 16 Aug., 1944, in buttresses of large tree (1 ♀); Cerro Tute, Santa Fe, Veraguas Province, Panama, 20 March, 1947, in buttress of tree (1 ♂); Canal Zone Police Substation, Rio Pequeni, Madden Lake, C. Z., 22 June, 1944, in buttresses (1 ♂); Juan Mina, Chagres river region, C. Z., 30 May, 1944, in hollow tree with bats (1 ♂); Puerto Pilon, Colon Province, Panama, 2 Feb., 1947, in buttresses (3 ♂).

We have only once encountered this species in numbers, in an animal burrow, and nearly all were males. It seems to show no special predilection for bats, and we have no clear indication of what its preferred host may be.

Phlebotomus deleoni sp. nov.

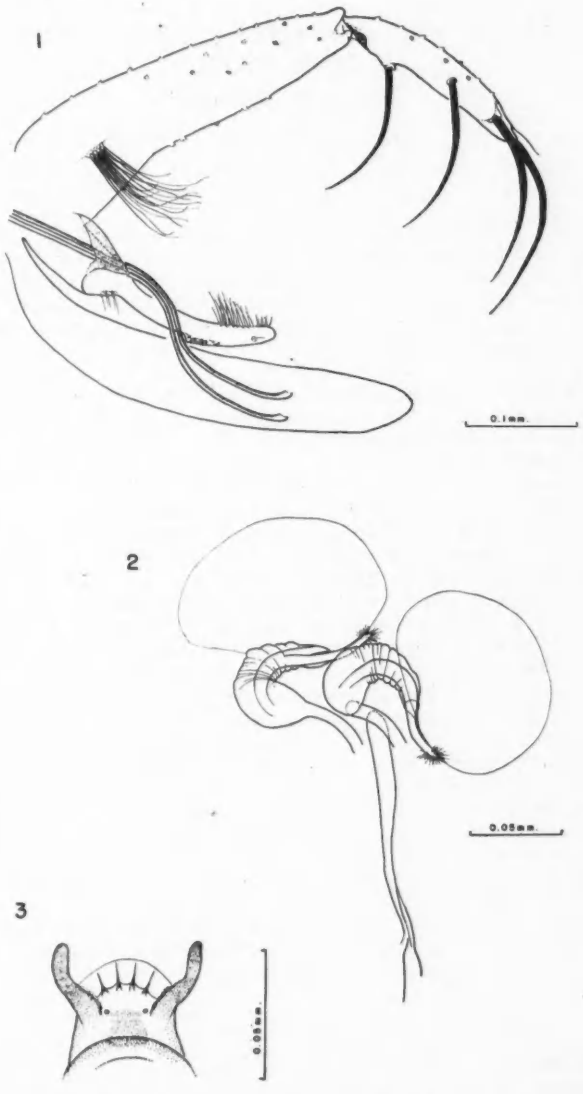
Plate III

Male—Genitalia as figured. This species differs most conspicuously from *vesiciferus* and *vespertilionis* in the possession of an additional spine on the style. The parameres have a ventral hook as in *vesiciferus*, not well shown in the figure, but are more slender than in that species. The genital filaments are of the same structure as those of *vesiciferus*, while the lateral lobes are long, as in *vespertilionis*.

Female.—Spermatheca and cibarium as figured. Pharynx apparently as in *vespertilionis*. The spermatheca was drawn from the *Allotype* cleared in phenol before mounting. The body of the spermatheca is smaller, the head longer and the inflated portion smaller than in *vesiciferus*, though these differences are hardly perceptible in mounted and shrunken material. The cibarium of our single specimen seems to show the teeth more widely separated and not so deeply set between the posterior arms as in *vesiciferus*.

Holotype male, Slide 777, and *allotype* female, Slide 778, Canchacan, Peten, Guatemala, July, 1946, Dr. J. R. de Leon coll. Taken in holes in limestone rock in association with a species of Nemopalpus.

The differences between this and *vesiciferus*, with the exception of the style, are slight, and the two are obviously very closely related. Cases such as this indicate the difficulty of attempting to group the species of *Phlebotomus* by means of such obvious genitalic characters as the number of spines on the style.



Phlebotomus deleoni. FIG. 1, male genitalia, inner aspect. FIG. 2, spermathecae, from specimen in phenol after KOH and staining. Ducts not further visible. FIG. 3, female cibarium, remainder not clearly visible.

THE AEDES (FINLAYA) CHRYSOLINEATUS GROUP OF MOSQUITOES
(Diptera: Culicidae)[1]

KENNETH L. KNIGHT,
Lt. Commander, MSC, USN

Edwards (1932) created "Group D (*chrysolineata* group: *Hulecoeteomyia*)" for all *Finlaya* species having the following characters: hind tarsi with 3 or more basal white bands, sometimes with apical bands also; femora not lined anteriorly; scutum with distinct narrow longitudinal lines of white or golden scales; and scales of vertex usually mostly narrow. He considered it an Oriental group with an extension into the Australasian region.

An examination of types in the British Museum, in addition to the opportunity to study some new material in the U. S. National Museum, has disclosed additional information on this group.

On the basis of this study, the group has been redefined as follows: (1) Male palpi with segments straight (not swollen or curved), a few hairs present at the apices of the terminal 3 segments, none or very few hairs laterally along the shafts of the apical 2 segments (may be up to about 7 lateral hairs on either side of IV and about 4 on either side of V in a few species), the palpi distinctly shorter than the proboscis (approximately ¾ths to ⅘ths). (2) Female torus scaled mesally. (3) Scutum with a scale pattern of distinct whitish-yellow or yellow longitudinal lines. (4) Postspiracular area with a patch of scales (confluent with the postspiracular hairs). (5) Fore and mid femora not possessing a complete median longitudinal pale line anteriorly, nor are the tibiae lined anteriorly. (6) Halter knob dark scaled on one side, pale scaled on the other. (7) Hind tarsi with basal bands only, located on the first 3–4 segments (occasionally a few basal pale scales on V in *koreicus*). (8) Oriental in distribution.

The group of species created by this definition has more the characteristics of a "superspecies" than it does of a "group" ("group" as used by Edwards, 1932). However, the use of the term "group" is continued here because of its well-established use in this subgenus.

Since the *chrysolineatus* group is made up of such closely related species, its members have a number of characters in common (in addition to the more basic ones used for the group definition). Consequently, in order to simplify the species descriptions contained in this

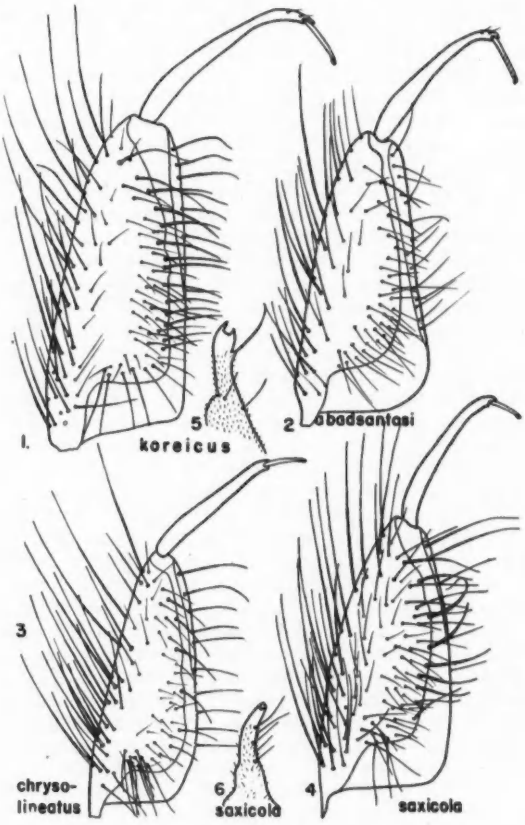
[1]This is the sixth paper of a series prepared in part on collections made in the Philippine Islands under the auspices of U. S. Naval Medical Research Unit No. 2. The work was done in space furnished by the Division of Insects, U. S. National Museum. Additional specimens were made available from the U.S.N.M. through the courtesy of Dr. Alan Stone. Mr. N. D. Riley and Mr. H. Oldroyd gave the fullest assistance in making it possible to examine the types in the British Museum. Mr. R. L. Ingram made the original larval studies for this paper. Mr. F. E. Baisas, Philippine Bureau of Health, very kindly loaned type material for comparison.

paper, these characters are summarized here, and will not be repeated in the descriptions unless subject to variation.

Male.—*Head*: Palpus shorter than the proboscis (about ¾ths to ⅘ths), the segments straight, not noticeably swollen or curved, nearly hairless except for a few bristles at the apices of segments III–V (may also be a very few laterally along the shafts of segments IV–V in some species, up to about 7 lateral hairs on either side of IV and about 4 on either side of V). Vertex with a longitudinal median band of narrow pale scales, this band widened posteriorly into a broad sparse patch, a line of similar scales along the median half of the eye margins; an area of dark scales between the ocular pale line and the posterior patch of narrow pale scales; lateral portion of vertex with broad pale scales, a small anterior patch of dark scales usually visible medially in this area; forked upright scales abundant dorsally from eye margin to nape, pale medially, dusky laterally (sometimes all pale except on submedian dark scaled areas). *Thorax*: Scutal integument brown; covered with small narrow brown and pale (creamy to yellow) scales, the pale scales arranged in full length narrow longitudinal lines as follows: a distinct median line, a submedian line that tends to be broken at the scutal angle (the anterior end of the posterior portion of the line is frequently curved outward along the scutal angle), a line over the wing base (this may be just a diffused area in some species), and a small patch of long narrow curved pale scales just before the wing base. Lateral scutellar lobes with sparse narrow scales, usually dark; mid lobe with broadened flat-lying dark scales laterally, a median longitudinal area of narrower yellowish scales. Pleuron with a patch of broad white scales on each of the following areas: proepisternal (propleural), postspiracular, prealar (below the knob), upper sternopleural, lower-posterior sternopleural, and upper half or more of the mesepimeral (some species also have scales on the paratergite and on the subspiracular region, or on both). Coxae with broad white scales, fore and mid also with dark scales ventrally, and fore usually with some white scales antero-ventrad to the dark scales. Posterior surface of fore femur with a broad dorsal white band from near base to apex (may be interrupted or diminished subapically). Posterior surface of mid femur with basal half largely white, this white continued along the apical half as a ventral band. Anterior surface of hind femur with a broad white area from near base to region of middle, connecting ventrally with a similar area on the posterior surface; dorsal surface usually dark along whole length; apex white beneath, this extending apico-dorsally onto both anterior and posterior surfaces. Tibiae with a baso-ventral white area, this extending laterally a variable amount. Fore and mid tarsal claws unequal, the larger claw with a normal median tooth and a finer acute latero-basal tooth, smaller claw with a subbasal tooth; hind claws equal, simple. Wing dark scaled, nearly always a ventro-basal line of white scales (may be reduced to scattered pale scales) on the costa; 2-3 stout hairs near the base of vein 1. Halter pale, knob with both dark and pale scales. *Abdomen*: Tergite I with lateral margin white scaled, remainder of segments with prominent baso-lateral white spots; usually some dorsal basal pale scaling or even complete basal bands present. Most of the sternites with basal white bands.

Female.—In general, similar to the male. Palpus about one-fifth to one-fourth the length of the proboscis. Torus with a patch of broadened scales mesally. Forked upright scales of vertex usually all dark. Tarsal claws equal, fore and mid each with one tooth, hind simple. Dorsal markings of tergites absent, or at least usually more reduced than in male; dorso-lateral markings as in male.

On the basis of this characterization of the *chrysolineatus* group, it is necessary to exclude the following species which were placed there by Edwards (1932): *aureostriatus* (Doleschall), *lauriei* (Carter), *quinque-*



FIGS. 1 (Korea), 2 (Samar, P. Is.), 3 (Bombay), and 4 (Palawan, P. Is.). Inner tergal aspect of basistyle of male genitalia. FIGS. 5(Korea) and 6 (Palawan). Lateral aspect of basal portion of dissected claspette of male genitalia.

In each case the general geographical locality is given for the specimen from which the drawing was made.

lineatus Edwards, *shortti* (Barraud), and *sintoni* (Barraud). Since Edwards' (1932) erection of this group, the following species have been described that belong to it: *abadsantosi* Baisas, *burgosi* Baisas, and *harveyi* var. *nigrorhynchus* Brug. The list of included species now stands as follows: *abadsantosi*, *burgosi*, *chrysolineatus*, *formosensis*, *harveyi*, *h.* var. *nigrorhynchus*, *japonicus*, *jugraensis*, *koreicus*, *pallirostris*, *rizali*, and *saxicola*. In addition, one new species is described in this paper.

In the treatments of species that follow, the distribution records listed from the literature do not include the type localities.

Specimens were examined from the collections of the U. S. National Museum (U. S. N. M.), Academy of Natural Sciences of Philadelphia (A. N. S. P.), British Museum of Natural History (Brit. Mus.), and Cornell University.

EXPLANATION OF SYMBOLS

apn = anterior pronotum (prothoracic lobe) of adult.
ppn = posterior pronotum (proepimeron) of adult.
lh = lateral hair of larval anal plate.
isc = inner (submedian dorsal) caudal hair of larval anal segment.

KEY TO THE ADULTS[2]

1. Scutum with median longitudinal pale line not forked posteriorly.....2
   Scutum with median longitudinal pale line forked posteriorly at the prescutellar bare space.....4
2. Hind tarsi with the first four segments with basal white scaling.....**sherki**
   Hind tarsi with only the first three segments with basal white scaling.....3
3.[3] Prealar scale patch continuous with the upper sternopleural scale patch, **jugraensis**
   Prealar scale patch distinctly separated from the upper sternopleural scale patch.....**abadsantosi**
4. Proboscis all dark scaled.....**burgosi** 5[4]
   Proboscis with pale scaling present.....7
5. Scutum with median longitudinal line not appearing double; torus of female with dark scales only; mid femora with anterior and antero-dorsal surfaces dark apically.....**saxicola**
   Scutum with median longitudinal line broad, appearing double; torus of female with most of the scales white; mid femora with a dorso-apical white area.....6
6. Hind tarsi with the first three segments basally banded; subspiracular area (area below spiracle along anterior sterno-pleural margin) without scales; *ppn* with some creamy narrow curved scales dorsally (usually numerous broad white scales present elsewhere).....**japonicus**
   Hind tarsi with first four segments basally banded (may be a few basal pale scales on V); subspiracular area with a line of broad white scales; *ppn* with broad white scales (usually a few narrow curved scales also present), **koreicus**
7. Paratergite with a line of broad white scales; subspiracular area with a small patch of broad white scales; prealar scale patch distinctly separated from the upper sternopleural scale patch.....8
   Paratergite and subspiracular areas without scales; prealar scale patch continuous with the upper sternopleural scale patch.....9

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[2]The males of *h.* var. *nigrorhynchus*, *pallirostris*, and *rizali* are unknown; and no adults of *h.* var. *nigrorhynchus* and *rizali* have been seen during this study.

[3]Since the type description of *rizali* (Banks) is incomplete on a number of points, it has been impossible to take it beyond this point in the key.

[4]From the type description it is impossible to key *h.* var. *nigrorhynchus* beyond this point.

8. Female proboscis mainly pale scaled on all aspects of the basal four-fifths except for a narrow basal dark ring.....**pallirostris**
Female proboscis with ventral and lateral pale scaling, but without a dorsal pale area.....**formosensis**
9. *Ppn* with many broad white scales; mid femur nearly always with anterior pale scales; female proboscis with ventral pale scaled area broadly produced onto the dorsal surface distad of the middle.....**chrysolineatus**
Ppn with narrow yellowish scales above and some broad white scales posteriorly; mid femur with the anterior surface all dark; female proboscis pale beneath medially, dark laterally and dorsally.....**harveyi**

KEY TO THE LARVAE[6]

1. The apical 2–5 pecten teeth ventrally out of line with the others (fig. 8), **abadsantosi**[6] **sherki**
The apical 2–5 pecten teeth not ventrally out of line with the others (fig. 7)...2
2. At least the anterior comb scales with expanded apices, and each with a rather even apical fringe (fig. 9); (*lh* single).....3
Comb scales tapered apically, the median apical fringe element noticeably more developed than the others (fig. 7).....5
3. Only the anterior comb scales broad apically, the posterior scales thornlike, **formosensis**
All the comb scales broad apically (fig. 9).....4
4. No simple pecten teeth beyond the base of the siphon hair tuft (fig. 14); anal plate with mostly spiculate scales on the posterior margin.....**koreicus**
Usually one or more enlarged simple teeth beyond the base of the siphon hair tuft (all the pecten teeth of different type than in *koreicus*, fig. 9); anal plate with mostly simple spines on the posterior margin.....**japonicus**
5. Metathoracic hair 7 with normal slender elongate branching (fig. 13); *lh* with 2 or more branches.....6
Metathoracic hair 7 with relatively short stout stellate-like barbed branches (fig. 11); *lh* single.....8
6. *Lh* with 3–4 branches.....**chrysolineatus**
Lh double.....7
7. No pecten teeth beyond the base of the siphon hair tuft..**h.** var. **nigrorhynchus**
Several pecten teeth between the base of the siphon hair tuft and the apex of the siphon.....**burgosi**
8. No simple (without denticles) pecten teeth apically (and apparently no teeth distad of the siphon hair tuft base).....**jugraensis**
Two to four simple pecten teeth beyond the base of the siphon hair tuft, and usually one to three simple teeth basad of the hair tuft.....9
9. Mesothoracic hair 1 with 2–4 branches; metathoracic hair 1 with 1–5 branches (fig. 11).....**saxicola**
Mesothoracic hair 1 with 8–9 branches; metathoracic hair 1 with 11–14 branches.....**Fin.** sp., near **saxicola**..

Aedes (Finlaya) saxicola Edwards, 1922

Figs. 4, 6, 10, 11, 12

1908. *Hulecoeteomyia fluviatilis* Leicester (nec Lutz, 1904), Cul. Malaya, p. 111 (male, female). TYPE-LOC.: Malay Penin. Ulu Gombak (Leicester). TYPE: Non-existant.
1922. *Aedes* (*Finlaya*) *saxicola* Edwards, Ind. Jour. Med. Res. 10: 466 (nom. nov.).
1923. *Finlaya greigi* Barraud, Bull. Ent. Res. 13: 406 (male, female). TYPE-LOC.: Assam. Haflong, Cachar Hills (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.

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[5]The larvae of *harveyi*, *pallirostris*, and *rizali* are unknown; and no specimens of *chrysolineatus*, *formosensis*, *h.* var. *nigrorhynchus*, and *jugraensis* have been seen by me.

[6]No completely adequate means of separating the larvae of these two species has been discovered.

1932. *A.* (*F.*) *saxicola* Edwards, Genera Insectorum, fasc. 194: 151. Synonymy of *greigi*.
1946. *Aedes* (*Finlaya*) *rizali* Banks, Baisas, Phil. Mon. Bull. Bur. Health 22: 21.

ADULT (Description from Philippine specimens). *Male.*—Wing approximately 2.8–3.2 mm. in length. Proboscis all black scaled. Palpus dark, a small basal white area (incomplete dorsally and laterally) on the apical segment. Median scutal line forked at prescutellar bare space. Posterior portion of submedian scutal line broken at the scutal angle, the anterior end of this portion curved outward along the scutal angle for a short distance, this posterior portion of the submedian scutal line is slightly more lateral than the anterior portion. *Apn* with broad creamy scales, some of the dorsal scales narrow; *ppn* with a dorsal and posterior band of narrow yellowish scales, some of the posterior scales may be broader and paler. Anterior surface of fore femur dark except for a pale ventro-basal line; anterior surface of mid femur marked by a median broad white area that begins near the base and tapers apically to a point near the middle (sometimes also a few apical pale scales). Tibiae dark, fore with a pale posterior line that is baso-ventrally broadened onto the anterior surface, mid and hind with a baso-ventral area of white that extends slightly onto the anterior and posterior surfaces. Fore and mid tarsi with narrow basal white rings on I–II, hind tarsus with broad basal bands on I–III, that on III being the widest and occupying the basal two-fifths of the segment (partially broken ventrally by dark scales). Tergites with a small baso-median patch of pale scales on III–VII (may be reduced to just a few scales on some segments), the outer margins of which may join with the baso-lateral white spots on some segments. *Genitalia* (figs. 4 and 6): Basistyle with outer surfaces dark scaled. Claspette stem pilose, with about 5 distinct hairs; claspette blade broadened medially. Ninth tergite lobes divided, with 7–13 hairs on each lobe. Ninth sternite with 2 stout bristles and 1–3 slender hairs (frequently there is a scale associated with these).

Female.—Differs from the male chiefly as follows: Wing approximately 3.5 mm. in length. Palpus with a few pale scales apically. Torus with scales all dark. Vertex with the upright-forked scales dark. Fore tibia all dark except for a small baso-ventral white spot. Tergites dorsally dark except for VII–VIII where the baso-lateral white spots extend prominently onto the dorsum, those on VIII sometimes forming a complete band; occasionally a few median basal pale scales present on some of the other tergites.

A small amount of variation was noted. The anterior portion of the scutal submedian line tends to become partially obsolete; the anterior pale area on the mid femur can be greatly reduced, or even missing (this variation was also noted in the Malayan and Indian specimens in the British Museum; the male type of *greigi* has the marking present, whereas it is absent in the female type); and the dorso-basal spots of tergites III–VI (in male) may occasionally form narrow basal bands by connecting laterally with the baso-lateral spots.

LARVA (description from 6 adult-associated skins from Palawan). *Head* (fig. 10): Integument with a fine droplet-like rugosity. Antenna

with scattered spicules; antennal hair inserted approximately at middle, 2–3 branched. Hair 4 very small, with 3–5 branches; 5, 6, and 7 with 4–7; 8, 13, and 14 single; 9 double (rarely single); 12 with 3–5; 15 and 17 with 2–4 (17 once with 5); 18 with 1–3; 20 very small, with 3–5; hairs 4, 5, and 6 very nearly in a straight horizontal line, 7 posterior to this line; hairs 17 and 18 stellate in type. Median mouth brush hairs with prominent comb-like tips. Mentum with 11–14 teeth on either side, the first 3–4 teeth more widely spaced.

Thorax (fig. 11): Prothoracic hair 0 very small, with about 15 fine branches; hair 1 with 2–4; 2 single; 3 with 3–5; 13 double. Mesothoracic hair 1 stout, stellate, with 1–4 barbed, elongate branches; 9 large, with 5–6; 10 and 12 stout, elongate, single; hair 11 minute, double, hair 13 minute, with about 12 fine branches. Metathoracic hair 1 stellate, with 1–5 short branches; 7 very stout, stellate, with 3–5 barbed branches; 9 large, with 3; 10 and 11 as on mesothorax, 12 short, slender, single; 13 minute, with about 10 fine branches. The tubercle that arises from the base of the meso- and metathoracic pleural hair tufts with a distinct tapered projection, which however, is shorter in length than the length of the sclerotized base of the hair tufts.

Abdomen (fig. 12): Integument with a small amount of very fine unbranched pile posteriorly. Some stellate hairs present. Dorsolateral hair (hair 6) of I and II double, occasionally triple, one branch longer than the others. Lateral hair (hair 7) of I–II single; of III–VI (hair 6) with 1–3 branches (usually double), where 2 or more branches are present one is usually longer. Hair 2 of III–VII stellate, with 1–3 branches. Pentad hair 1 with 1–2 branches, 2 and 4 single, 3 with 7–9 frayed branches, 5 with 2–3 stellate branches. Comb scales in a patch, 55–70 in number, tapered, ending in a stout apical spine, lateral fringe from near base of shaft to apex. Siphon pale yellowish-brown, with transverse striations distinctly visible at 90x; index 2.2 to 2.9; acus present, attached; hair tuft inserted just beyond middle, with 5–7 frayed branches that do not reach the siphon apex; pecten composed of an even line of 12–17 dark teeth that extends nearly to the siphon apex (tip of apical tooth sometimes reaching the siphon apex), each tooth larger than the previous one, 2–4 teeth beyond the base of the siphon hair tuft, these teeth and about the first 1–3 before the hair tuft nearly always simple, the remainder of the teeth with 1–2 ventral denticles. Anal plate incomplete ventrally, with transverse lines of minute spicules, numerous spines along posterior margin; *lh* stout, single, barbed, slightly longer than anal plate; *isc* with 3–5 branches. Ventral brush with 12 tufts, all arising from a conspicuous barred area; each tuft with 3–9 branches. Anal gills slender, tapered rather evenly, dorsal pair slightly longer than the ventral pair and 2.5–3 times longer than the anal plate.

Great variation occurs in this larva in the size of the barbed hairs and in the number of their branches.

HABITAT. The larva is commonly found in rock holes and pools in the beds of jungle streams. Causey (1937) collected the larvae from rock pools that were free of visible vegetation and fully exposed to the sun. One record in the U. S. N. M. is from a coconut shell but it seems

possible that this is in error. However, Barraud (1923) reported collecting a larva from a tree hole.

REMARKS. The identification of the Philippine specimens described above is based upon a comparison made in the British Museum with the types of *greigi*, and with some Malayan specimens. According to Edwards (1923), Leicester's types of *fluviatilis* have been lost.

The only possible significant difference noted between the types and the Philippine specimens was that the bases of the wing fork-cells are nearly on a level in the Indian and Malayan specimens, whereas the posterior cell begins definitely nearer to the wing base in the P. I. specimens. The male genitalia agreed well with that of a specimen from Malaya. The larva appears to agree satisfactorily with the published descriptions for *saxicola*.

Baisas (1946) selected a male and female (from Palawan) of this species as novotypes for *rizali*, and described them and the larva and pupa as a redescription for *rizali*.

This species, although nearest to *japonicus* and *koreicus*, more or less stands alone in the group.

DISTRIBUTION. *Specimens examined.* U. S. N. M. (9 males, 8 females, 5 larva, 5 sets of adult-associated larval and pupal skins): *Philippines.* Palawan: (H. Hoogstraal); Irahuan and Balsahan Rivers (D. R. Johnson, J. L. Laffoon, A. T. Fitzjarrell). Brit. Mus. (1 male, 3 females): *Malaya.* Cameron's Highlands, 3500 ft (H. P. Hacker).

Additional records from the literature. Malaya. Wray's Hill, Pahang (Edwards, 1928); Pulai Oban, Singapore (Edwards and Givens, 1928). *Java.* Mt. Salak (Barraud, 1934). *Siam* (Causey, 1937). *India.* Eastern Himalayas: Kurseong, Darjeeling dist., 5,000 ft. (Barraud, 1934).

Aedes (Finlaya) japonicus (Theobald), 1901

Fig. 9

1901. *Culex japonicus* Theobald, Mon. Cul. 1: 385 (female). TYPE-LOC.: Japan. Tokyo (Woods). TYPE: Female (2 cotypes) in Brit. Mus.

1921. *Aëdes (Finlaya) eucleptes* Dyar, Insc. Mens. 9: 147 (male and female). TYPE-LOC.: China. Canton (Howard). TYPE: Male (holotype) in U.S.N.M. Male genitalia mounted.

1922. *Aedes (Finlaya) japonicus* Theo. Edwards, Ind. Jour. Med. Res. 10: 465. Synonymy of *eucleptes*.

ADULT. Differs from *saxicola* as follows: *Male.*—Wing approximately 3.5 mm. in length. Palpus all dark. Median scutal line broad, tending to appear double; submedian line double on posterior half, the anterior end of the outer portion bending outward along scutal angle; a broad diffused pale area over wing bases. Lateral scutellar lobes with also a few pale yellow narrow scales (may occasionally be only pale scales on all lobes). *Apn* with an oblique band of broad white scales; *ppn* with yellowish narrow-curved scales anteriorly and dorsally, some of the posterior scales usually broad and whitish, usually a few narrow scales present (the type and distribution of the scales on this area seem to be subject to considerable variation). Mid femur dark anteriorly except for a dorso-apical white area (may be a few pale scales along the median longitudinal line); hind femur with the

median anterior white area usually continuous, at least narrowly, to base (the basal extent of this marking apparently subject to much variation), apical pale area forming a complete ring at apex. *Genitalia:* Arrangement of hairs on the inner tergal surface of the basistyle in general similar to that of *saxicola* (see fig. 4); except that there are fewer stout hairs, about 4, on the inner margin of this surface. Claspette stem pilose, with 3 distinct hairs (generally similar to that of *koreicus*, fig. 5); claspette blade swollen medially (resembling that of *saxicola*). Ninth tergite lobes each with 5–8 hairs. Ninth sternite with about 5 rather equal hairs, none distinctly larger than the others (the type of *eucleptes* has only 2 bristles here).

Female.—Wing approximately 3.9 mm. in length. Palpus dark. Torus with white and dark scales present mesally. Scutal pattern similar to that of male except that the inner portion of the posterior half of the submedian line is obsolete.

The extent of the basal pale scaled area on the ventral surface of the costal vein is variable in this species, being reduced to only a few pale scales in some males, and completely missing in the 3 females seen.

LARVA (description from 3 larvae from Nagasaki, Kyushu). Similar to *saxicola* in general details but differing chiefly as follows: *Head:* Integument not rugose. *Thorax:* No definitely developed stellate hairs. Prothoracic hair 0 with about 4–7 branches; hair 1 of the meso- and metathorax and hair 7 of the metathorax without noticeable development. *Abdomen* (fig. 9): Integument non-pilose. No definitely developed stellate hairs. Hairs 1 and 2 of segments III–VI slender, single. Comb scales about 45–60 in number, broadened apically and with a rather even lateral and apical fringe. Pecten composed of about 15–22 teeth, 2–3 teeth distinctly beyond the base of the siphon hair tuft, the more apical 1–2 of these simple, the remainder of the teeth beyond the hair tuft and before it with 2–4 serrate denticles each. Posterior margin of anal plate with only a few spines; *lh* single, smooth. Basal 1–2 tufts of ventral brush not arising from the barred area. Anal gills rather broadly lanceolate, approximately 1.5 times longer than the anal plate.

Three larvae from Kyoto, Honshu agreed with the above material except that 2 of the specimens had all the hair tufts of the ventral brush arising from the barred area; and one specimen on one side had only denticulate pecten teeth apically.

One important discrepancy between the above and the published descriptions has been noted. Li and Wu (1935, Hangchow) describe *lh* as being 2–4 branched.

HABITAT. The larva has been reported from granite cemetery basins (Edwards, 1921) from clear water in artificial containers near houses in hilly regions, and from hill stream rock holes (Feng, 1938). Feng (1938) reported that the female bites humans only sparingly.

REMARKS. The types of *japonicus* and *eucleptes* have been examined. This species has been commonly confused with *koreicus*, with which it is closely related, but it is well distinct from it on adult and larval characters. Stackleberg (1937) incorrectly ascribes the male genitalic drawing of *koreicus* by Ho (1931) to this species.

According to Yamada (1927), *japonicus* is not a suitable intermediate host of *W. bancrofti*. It has been reported as vector of Japanese encephalitis in the Soviet Far East by Chagin and Kondrat'yev (1943).

DISTRIBUTION. Specimens examined. U. S. N. M. (5 males, 3 females, 3 larvae): *Japan*. Honshu: Tokyo (S. Yamada). Kyushu: Nagasaki (D. J. Borror). W. J. LaCasse Coll. (3 females, 3 larvae): *Japan*. Honshu: Kyoto: Otsu (W. J. LaCasse).

Records from the literature. Japan. Honshu. Shikoku. Kyushu. (Yamada, 1927). *China*. Anhwei: Hwangshan. Chekiang: Hangchow; Hwangyen; Tienmushan; Yetangshan. Fukien: Kushan of Foochow. Kiangsi: Kirikiang. Kwangtung: Canton; Hongkong. (Feng, 1938). Formosa (Hsiao and Bohart, 1946). *Soviet Far East* (Chagin and Kondrat'yev, 1943).

Aedes (Finlaya) koreicus (Edwards), 1917

Figs. 1, 5, 14

1917. *Ochlerotatus* (*F.*) *koreicus* Edwards, Bull. Ent. Res. 7: 212 (male, female). TYPE-LOC.: Korea (Mills). TYPE: Male (holotype) in Brit. Mus. Male genitalia mounted.
1921. *Aëdes* (*Finlaya*) *koreicus* Edw. Edwards, Bull. Ent. Res. 12: 318.
1930. *Aëdes japonicus* Theo. Matheson, Bull. Brooklyn Ent. Soc. 25: 293.
1931. *Aëdes japonicus* Theo. var. *koreicus* Edwards. Ho, Bull. Fan Memorial Instit. Biol. 2: 127.
1936. *Aëdes* (*Finlaya*) *japonicus* Theobald (=*coreicus* Edw.). Montschadsky, Les Larves des Moustiques de L'URSS et des Pays Limitrophes, p. 301. In part.

ADULT. Differs from *saxicola* as follows: *Male*.—Wing approximately 3.4–3.8 mm. in length. Palpus all dark. Upright forked scales dark. Mid scutal line broad, tending to appear double; submedian line broken at level of scutal angle, the anterior end of the posterior portion extending outward along the scutal angle to the scutal margin; a diffused area of pale scales over the wing base. *Apn* with an oblique band of broad white scales; *ppn* with broad white scales, usually some narrow curved scales also present. Subspiracular area (below spiracle along dorso-anterior sternopleural margin) with a line of broad white scales (not noted in type). Fore femur usually with a ventro-apical anterior white spot; mid femur dark anteriorly except for an apical white ring; hind femur with anterior aspect white from base to just beyond middle except for a narrow dorsal line, apex with a complete white band. Fore tibia dark. Fore tarsus with a narrow basal white area on I–II, sometimes a few basal pale scales on III; mid tarsus with rather broader basal white bands on I–III, sometimes a few basal pale scales on IV; hind tarsus with broad basal white bands on I–IV, the band on IV largely broken ventrally, occasionally a few basal pale scales on V. Wing all dark scaled. *Genitalia* (figs. 1 and 5): Inner tergal surface of basistyle bearing fewer hairs than in *saxicola*. Claspette stem pilose, with 3 distinct hairs; claspette blade not particularly swollen medially. Ninth tergite lobes each with about 7–10 hairs. Ninth sternite with 2 large stout bristles and 2–4 slender hairs.

Female.—Wing approximately 3.8–5.1 mm. in length. Palpus all dark. Torus with broadened white scales mesally. Costa may have a few baso-ventral white scales.

A small amount of variation was noted in the extent of the white scaling of the legs described above.

LARVA (description from 5 larvae from Keijo and Seoul, Korea). Similar to *saxicola* in general details, but differing as follows: Integument of head not rugose. Thorax and abdomen without pilosity or definitely developed stellate hairs. Prothoracic hair 0 with about 4–8 branches; hair 1 of the meso- and metathorax and hair 7 of the metathorax without noticeable development. Lateral hair of abdominal segments I–II with 1–2 branches; of III with 3–4 branches; of IV with 2–3, of V–VI double. Hair 1 of III–VI small, single; hair 2 of III–VI slender, with 1–4 branches. Comb scales about 45–65 in number, broadened apically and with a rather even lateral and apical fringe. Siphon hair tuft (fig. 14) with 6–8 plumose branches; pecten composed of about 24–29 teeth, 0–4 teeth inserted beyond the base of the hair tuft, each tooth with 2–6 serrate ventral denticles. Posterior margin of anal plate with a few spiculate scales and sometimes a very few spines dorsally. Ventral brush with basal 1–2 tufts not arising from the barred area. Anal gills broadly lanceolate, dorsal pair about 1½ times longer than the anal plate and slightly longer than the ventral pair.

Although this larva has not previously been completely described, Edwards (Barraud, 1934) gave a diagnostic note from Peiping material, and Hsiao and Bohart (1946) figure the terminal segments of a Korean specimen.

HABITAT. Ho (1931) stated that this species is one of the common early mosquitoes in Peiping, appearing in the later part of spring. The larva is found in all types of artificial containers about homes, and apparently occasionally even in pools on rocks in the hills (Feng, 1938). Kobayashi (1933) reported that *koreicus* overwinters in the egg stage, hatching in the spring when the ice melts.

The adults will bite humans either day or night.

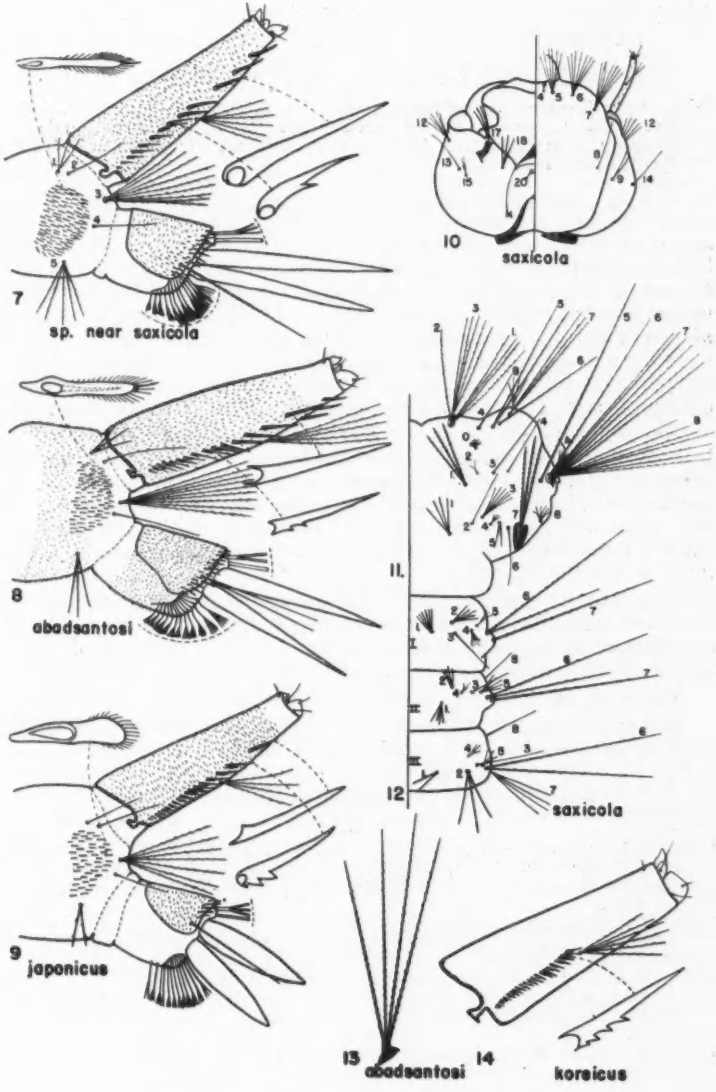
REMARKS. The type of *koreicus* has been examined. This species is so closely related to *japonicus* as to have been confused with it by various authors. It is distinct however, on the markings of the hind tarsi, and on the scaling of the subspiracular area.

Yamada (1927) found this species to be an unsuitable intermediate host of *W. bancrofti*. Feng (1938) reported that *koreicus* has been proven experimentally to be a good transmitter of *Dirofilaria immitis* to dogs in Peiping.

DISTRIBUTION. *Specimens examined.* U. S. N. M. (14 males, 30 females, 2 larvae): *Korea.* Seoul (E. Pace, I. Preitman, L. Carpelan); Keijo (L. Carpelan). *China.* Hopeh: Peiping (H. E. Meleney). W. J. LaCasse Coll. (3 larvae): *Korea.* Seoul (W. J. LaCasse).

EXPLANATION OF PLATE I

FIGS. 7 (Palawan), 8 (Samar), and 9 (Nagasaki, Kyushu). Lateral aspect of larval terminal segments. FIG. 10 (Palawan). Larval head; left half ventral, right half dorsal. FIG. 11 (Palawan). Right dorsal aspect of larval thorax. FIG. 12 (Palawan). Right dorsal aspect of first three abdominal segments. FIG. 13 (Samar). Larval metathoracic hair 7. FIG. 14 (Korea). Lateral aspect of larval siphon.


7
sp. near saxicola
10
saxicola
8
abadsantosi
11
saxicola
9
japonicus
12
13
abadsantosi
14
koreicus

Records from the literature: Japan. Hokkaido (Yamada, 1927). *China.* Hopeh: Pieping. Liaoning: Moukden. Shantung: Tsinan and Taishan (Feng, 1938). *Korea.* Seoul (Matheson, 1930).

Aedes (Finlaya) harveyi var. nigrorhynchus Brug. 1931

1931. *Aedes* (*Finlaya*) *harveyi* var. *nigrorhynchus* Brug, Arch. Hydrobiol. Suppl.-Bd. 9: 28 (female, associated larval skin). TYPE-LOC.: Java. Djajasana, Preanger Regentschappen, 1400 m. (Thienemann). TYPE: Female (? holotype), location unknown.

ADULT. Not seen. According to Brug (1931), the female of this species differs from *harveyi* in having the proboscis dark scaled. He stated further that all the males of the collection from which the type female of *nigrorhynchus* came were indistinguishable from the male of *harveyi*. But since Brug apparently had no associated skins for these males, it is impossible to say at present whether or not the male of *nigrorhynchus* is actually inseparable from that of *harveyi*, or whether there simply weren't any male *nigrorhynchus* in the collection. Apparently he had only one larval skin associated with a female with an all dark proboscis. No other adult characters are described by Brug.

LARVA. Brug (1931) stated that the larva of *nigrorhynchus* differs from that of *formosensis* (identified as *harveyi* by him) mainly as follows: antennal hair short, thickened; antennal spicules very small; the comb scales all spinelike, a lateral fringe present; posterior margin of the anal plate with only about 4 spines; *lh* double; and no pecten teeth beyond the siphon hair tuft (Brug's drawing shows at least 1 simple tooth before the hairtuft).

REMARKS. I did not see the type material of this species in the British Museum collection, although Brug stated in the foreword to the article in which *nigrorhynchus* was named, that the types of all species described in the paper were deposited there.

There are no other published records for this species.

Edwards (Barraud, 1934) believed it possible that the larva described by Brug as *nigrorhynchus* may actually be the larva of *harveyi*.

Aedes (Finlaya) chrysolineatus (Theobald), 1907

Fig. 3

1904. *Hulecoeteomyia trilineata* Leicester (nec Theobald, 1901), in Theobald, Entom. 27: 163 (male, female. TYPE-LOC.: Malaya. Kuala Lumpur (Leicester). TYPE: Male and female (cotypes) in Brit. Mus. Male genitalia mounted.

1907. *Howardina chrysolineata* Theobald, Mon. Cul. 4: 218 (single female). TYPE-LOC.: Ceylon. Pundabroya[7] (Green). TYPE: Female (holotype) in Brit. Mus.

1910. *Culex* (?) *japonicus* var. *ceylonica* Theobald, Mon. Cul. 5: 391 (2 females). TYPE-LOC.: Ceylon. Peradeniya (Green). TYPE: Female (1 cotype) in Brit. Mus. This species was described but not named in Theobald, Mon. Cul. 3: 158. 1903.

1913. *Stegomyia trilineata* (Leic.). Edwards, Bull. Ent. Res. 4: 226. Synonomized *chrysolineatus* Theobald by comparison of types.

1922. *Aedes* (*Finlaya*) *chrysolineatus* Theo. Edwards, Ind. Jour. Med. Res. 10: 466. Synonymy of *trilineata* Leicester, 1904.

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[7]Barraud (1934) gives this as Pundaluoya.

1923. *Finlaya trilineata* (Leic.). Barraud, Ind. Jour. Med. Res. 11: 500.
1932. *A.* (*F.*) *chrysolineatus* Theobald. Edwards, Genera Insectorum, fasc. 194: 151. Synonymy (questioned) of *japonicus* var. *ceylonica* Theobald. Error in quotation of original species reference for *ceylonica*.

ADULT. Closely resembles *saxicola* but differs chiefly as follows: *Male*.—Palpi with pale scaling at the joints of III–IV and IV–V, remaining segments dark. Proboscis pale beneath from near base to just beyond middle and also at apex, upper surface dark except for a narrow pale ring just distad of middle. Submedian scutal line with anterior portion complete, more definite. *Apn* with an oblique band of broad white scales; *ppn* with many broad white scales, largely along dorsal and posterior margins. Prealar scale patch continuous with the upper sternopleural patch. Fore femur anteriorly pale along ventral border; mid femur anteriorly dark, or with longitudinal median pale scaling; hind femur more extensively white beneath at tip. Hind tibia more extensively white beneath at base. *Genitalia* (fig. 3): Inner tergal surface of basistyle with arrangement of hairs generally similar to that of *koreicus* (see fig. 1) except that none of the setae immediately along the inner margin of this surface are nearly as broadened and stout as 2–3 of those on *koreicus*, nor are there quite so many setae in the setal band along the inner margin; also the setae along the basal margin of this surface are somewhat clumped so that the impression of a weak basal lobe is given. Claspette stem pilose, 5 distinct hairs present, the apical hair not distinctly longer than the others; claspette blade not widened medially (Barraud, 1934, fig. 37g). Ninth tergite lobes each with about 25 hairs. Ninth sternite with 2 bristles and about 2 hairs, several scales present.

Female.—Palpi broadly white-tipped, the exact amount of this white scaling is variable however. Proboscis ventrally pale scaled from near base to beyond middle, and at the apex; the pale scaling broadly produced onto the upper surface just distad of the middle (the dorsal midline may be dark or all pale); the exact amount of pale scaling on the proboscis is subject to considerable variation.

LARVA. No specimens of this larva were available for examination, but according to Barraud's (1934) description from Indian material it appears to closely resemble the larva of *saxicola*. The larva of *chrysolineatus* is apparently distinct however, in having metathoracic hair 7 with 6–8 normal branches (as in fig. 13), a comb of 26–30 teeth, *lh* with 3–4 branches, and the apical pecten tooth beyond the hair tuft not reaching near to the apex of the siphon (nor as much enlarged as it is in *saxicola*.

From Borel's (1928, 1930) figure of the larva, it seems possible that he is dealing in part, at least, with another species, for he shows *lh* to be single and the pecten without differentiated teeth beyond the hair tuft.

HABITAT. The larva has been reported from tree holes (Barraud, 1923a), from rock holes in a mountain stream (Causey, 1937), from bamboo (Leicester, 1908, and Barraud, 1924), from *Colocasia* (Brug, 1931), and from roof gutters and broken chatti (Barraud, 1934).

Leicester (1908) records the adult as being a sylvan biter.

REMARKS. There had previously been no specimens labeled as the

types of *ceylonica* Theobald in the British Museum. However, on request, Mr. P. F. Mattingly, of that institution, very kindly looked through the *chrysolineatus* series and found the October-collected female referred to by Theobald. This specimen is now labeled as a cotype of *ceylonica*. The female collected in June is apparently missing. From a description of the pleural scaling sent by Mr. Mattingly there apparently can be no doubt but that *ceylonica* is a synonym of *chrysolineatus*.

The types of *trilineata* and *chrysolineatus* were examined by me.

DISTRIBUTION. *Specimens examined.* U. S. N. M. (3 males, 3 females): *India.* Bombay: Nagargali and Deccan jungle (P. J. Barraud).

Records from the literature. India. Bombay: Deccan; Nagargali; North Kanara; Kadra; Yellapur. Malabar: Pudupadi. Eastern Himalayas: Kurseong. Ceylon: Suduganga, Matale Dist. (Barraud, 1934). *Siam.* Patalung Pass (Causey, 1937). *Malaya:* Bukit Kutu and Ulu Gombak, near Kuala Lumpur (Leicester, 1908). *Java.* Ngledok (Brug, 1931); Tosari (Theobald, 1911). *Indochina.* Cochinchina (Borel, 1928).

Aedes (Finlaya) harveyi (Barraud), 1923

1923. *Finlaya harveyi* Barraud, Bull. Ent. Res. 13: 407 (male, female). TYPE-LOC.: India. Eastern Himalayas; Kurseong, Darjeeling dist. (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.

1931. *Aedes (Finlaya) harveyi* (Barr.). Brug. Arch. Hydrobiol. Suppl.-Bd. 9: 26. At least in part *formosensis.*

ADULT. Differs from *saxicola* as follows: *Male.*—Proboscis with a narrow pale ring near middle, complete except for a narrow median dorsal dark line. Palpi with basal pale scaling on IV, a few pale scales between II–III. *Apn* with broad white scales; *ppn* with narrow yellowish scales above and some broad white scales down the posterior margin. Prealar scale patch continuous with the dorsal sternopleural scale patch. Mid femur with anterior surface dark. Tibiae dark except for a small ventro-basal white area. Third hind tarsi segment with basal band occupying slightly over one-half of the segment dorsally. Abdominal tergites with white basal bands. *Genitalia:* Setae of the inner tergal surface of basistyle similar in arrangement and type to those of *abad-santosi* (fig. 2), except that a weak basal lobe is present with some of its setae more or less clumped. Claspette stem pilose, with 3 distinct hairs, the distal one not longer than the others; claspette blade not enlarged medially (Barraud, 1934, fig. 37j), tapered from before middle to apex. Ninth tergite lobes each with 18–24 hairs. Ninth sternite with 2 bristles and 4 short hairs.

Female.—Proboscis pale beneath medially, dark laterally and dorsally, the ventral area distad of the pale scaling black, the portion caudad of the marking usually paler. Tergites without dorsal markings.

LARVA. The larva is apparently undescribed. Brug (1931) described a series of larvae from Java, Bali, and Sumatra which he identified as this species. However, Edwards (Barraud, 1934) examined the adults associated with two of the larval skins (from Bali) contained in Brug's series and has pointed out that these are apparently *formosensis.*

Edwards states further that it is possible that the larva described by Brug (1931) as *harveyi* var. *nigrorhynchus* may be the larva of *harveyi*, but that this is not certain. In writing to Brug on this matter, Edwards incorrectly referred the two skins that he had studied to Sumatra. On the basis of this, Brug (1932) stated that the larvae from Sumatra were *formosensis* and those from Java and Bali were *harveyi* and stated that the latter differed from *formosensis* in having the antennal hair tuft before the middle instead of beyond, and in having 2 pecten teeth beyond the siphon hair tuft with one of these near the end of the siphon (instead of just one tooth beyond and it near to the hair tuft). Since Brug made this division on the incorrect information of Edwards, the correct identity of the larva of *harveyi* still remains in doubt.

DISTRIBUTION. *Specimens examined*, U. S. N. M (1 male, 1 female): *India*. Eastern Himalayas: Kurseong, Darjeeling dist. (P. J. Barraud).

Records from the literature. India. Eastern Himalayas: Kurseong, Mungpoo, Sureil, Tindharia, Sukna, all in Darjeeling dist. Madras: Coonoor. South India: Mercaria, Coorg (Barraud, 1934). *Sumatra.* Lake Ranau, 700 m., Boekit Daoen (Brug and Edwards, 1931). ? *Java.* ? *Bali.* (Brug, 1931).

Aedes (Finlaya) formosensis Yamada, 1921

1921. *Aëdes formosensis* Yamada, Annot. Zool. Jap. 10: 67 (female). TYPE-LOC. Formosa. Kakubanzan (Hirayama). TYPE: Female (2 cotypes), location: unknown.
1922. *Aedes formosaensis* Yam. Edwards, Ind. Jour. Med. Res. 10: 262.
1923. *Finlaya khasiana* Barraud, Bull. Ent. Res. 13: 407 (male, female). TYPE-LOC.: Assam. Shillong, Khasi Hills (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.
1931. *Aedes* (*Finlaya*) *harveyi* (Barr.) Brug, Arch. Hydrobiol. Suppl.-Bd. 9: 26. In part, at least.
1932. *A.* (*F.*) *formosensis* Yamada. Edwards, Genera Insectorum, fasc. 194: 151. Synonymy of *khasiana*.

ADULT. Differs from *saxicola* as follows: *Male.*—Proboscis with a ventral and lateral pale area just beyond the middle. Palpus dark, a small basal white area on segments III, IV, and V. *Apn* with broad white scales. Paratergite with a line of broad white scales. Subspiracular area with a small patch of broad white scales. Fore and mid tarsi with narrow basal white rings on I–III; hind tarsus with broad basal bands on I–III, that on III occupying about one-half of the segment. *Genitalia:* The genitalia of this species has not been fully described, nor has a specimen been available for this study. Barraud (1934, fig. 37i) does figure the claspette blade and the ninth sternite, however.

Female.—Torus with pale scales medially. Proboscis with the baso-ventral and lateral three-fourths pale scaled, the pale scaling scarcely visible from above.

The above description is based upon an examination of the types of *khasiana*. That this species may not be cospecific with *formosensis* is evident from Yamada's type description in which he describes the female palpus as having a few white scales at the tip of the penultimate segment, in addition to the apical ones; the female proboscis as having only about the middle one-half with lateral and ventral white scales;

the torus bearing a patch of flat black scales; and *apn* with some of the broad scales curved. Final determination of this point must await the examination of the types of *formosensis*. Unfortunately, it is not known on what basis Edwards made this synonomy. The presence or absence of scale patches on the paratergite and on the subspiracular areas will do much to determine whether or not those species are cospecific or not.

LARVA. No specimens were available for examination, but according to Edwards' (Barraud, 1934) description of 2 larval skins from Bali, the larva of *formosensis* apparently differs from that of *saxicola* as follows: metathoracic hair 7 with 6–7 long branches (not modified) and arising from a small inconspicuous plate; comb scales 25–40 in number, the anterior ones enlarged apically and apically fringed, the posterior teeth spinelike and with only a lateral fringe; pecten with only about 10 teeth, those basad of the hair tuft with strong basal denticles, only 1–2 (without denticles and not specially produced) beyond the hair tuft; siphon hair tuft with 3 branches; (*lh* single); and *isc* with 2 branches.

The 2 larval skins from Bali described by Edwards are from a series described by Brug (1931) as *harveyi*. However, the adults associated with these 2 skins are *formosensis* according to Edwards. Whether or not the remainder of the series (1 skin from Bali, 16 larvae from Sumatra, and 2 skins and 2 larvae from Java) are also *formosensis*, Edwards was unable to say since he hadn't seen the material.

HABITAT. In India, the larva of this species has been collected from bamboo stumps (Barraud). In the Dutch East Indies, it has been collected from the leaf axils of *Colocasia* (Brug). The remainder of Brug's Dutch East Indies collection records are at present not reliable due to a probable confusion with *harveyi*.

Barraud (1924) recorded taking a female in a house at Sureil.

REMARKS. As pointed out under the description of the adult, an examination of the types of *khasiana* Barraud showed that it may well be distinct from *formosensis*.

DISTRIBUTION. *Records from the literature. Assam.* Shillong; Golaghat; Nongpoh, Khasi Hills dist. *India.* E. Himalayas: Sureil; Kurseong (Barraud, 1934). *Bali.* Batoeriti (Baturiti), Kintamani. *Sumatra.* Ranau-See. ? *Java.* (Brug, 1931).

Aedes (Finlaya) pallirostris Edwards, 1922

1922. *Aedes* (*Finlaya*) *pallirostris* Edwards, Ind. Jour. Med. Res. 10: 270 (female). TYPE-LOC.: Assam. Golaghat, Sibsagar dist. (Christophers). TYPE: Female (holotype) in Brit. Mus.
1924. *Finlaya pallirostris* Edw. Barraud, Ind. Jour. Med. Res. 11: 855.

ADULT. Differs from *saxicola* mainly as follows: *Male.*—Unknown. *Female.*—Proboscis mainly pale on all aspects of basal four-fifths except for a narrow basal dark ring. *Apn* with broad white scales; *ppn* with narrow curved creamy scales dorsally and some broad creamy scales ventro-posteriorly. Paratergite with a line of broad white scales. Hind femur with some black scales beneath at extreme tip. Tergites II–VII each with a median basal white patch of scales. Sternites with some pale scaling towards hind margins, as well as basally.

LARVA. Unknown.

HABITAT. Type reared from bamboo stump.

REMARKS. The type has been examined. This species is very closely related to *formosensis* (Indian material), and Edwards (Barraud, 1934) suggests that it may in fact be just a variation of that species.

DISTRIBUTION. *Records from the literature. Assam.* Nongpoh (Barraud, 1924).

Aedes (Finlaya) abadsantosi Baisas, 1946

Figs. 2, 8, 13

1946. *Aedes* (*Finlaya*) *abadsantosi* Baisas, Phil. Mon. Bull. Bur. Health 22: 25 (male, female, pupa, larva). TYPE-LOC.: Philippines. Luzon Island: Llavac, Infanta Muni., Tayabas Province (Baisas). TYPE: Male (holotype) with assoc. larval and pupal skin mounts, in the Philippine Bureau of Health, Manila.

ADULT. Differs from *saxicola* as follows: *Male.*—Wing approximately 2.5–2.7 mm. in length. Palpus dark, a latero-basal white scaled area on III and IV. Median scutal line extends posteriorly nearly across the prescutellar area, not forked posteriorly, the submedian line is usually broken at the level of the scutal angle (even when not broken a division of the line usually bends briefly antero-laterally along the angle); the line over the wing base anteriorly nearly connects at the scutal angle with the outcurved portion of the submedian line (the extent of the submedian line laterally is variable and it is doubtful whether this constitutes a specific character as stated by Baisas). *Apn* with a few narrowed yellowish scales above, broad creamy scales below; *ppn* sparsely covered with narrow-curved yellowish scales, some of the posterior scales may be broadened, occasionally a few dark scales medially. Mid femur with anterior surface dark (occasionally a few scattered pale scales here). Fore and mid tibiae with a pale posterior line along whole length, a short basal white area anteriorly on the mid tibia, a baso-ventral pale area on the hind tibia. Tergites with complete broad basal white bands on III–VII (that on VII may be narrowed, or even broken, medially). *Genitalia* (fig. 2): Inner tergal surface of basistyle with none of the setae along the inner margin notably enlarged, the setae rather scanty along the apical portion of this margin, the posterior margin of the inner tergal surface not resembling a weak basal lobe (the inner tergal surface of this species greatly resembles that of *harveyi* except for the absence of a weak basal lobe). Claspette stem pilose, 2–3 distinct hairs, the apical hair usually only slightly longer than the others; claspette blade slightly widened medially. Ninth tergite lobes each with 6–10 bristles (Baisas gives 4–8). Ninth sternite with 2 bristles and 1–2 hairs (Baisas gives 2–7).

Female.—Wing approximately 2.6–3.1 mm. in length. Mid tibia dark except for a small basal pale area on both the anterior and posterior surfaces. Tergite II dark dorsally, or with a few median basal pale scales; III–VIII with complete basal white bands, occasionally the bands somewhat narrowed medially, and rarely even narrowly incomplete on one or more of any of the segments except VIII.

LARVA (description from 11 associated skins from Samar and Leyte). Differs from *saxicola* chiefly as follows: Integument of head not rugose.

Head hair 15 with 2–3 branches; hairs 17 and 18 (stellate) with 5–7; 20 with 2–3. Thoracic integument heavily pilose (pile simple or branched; Baisas described it as being unbranched). Prominent stellate hairs present. Prothoracic hair 0 small, with 7–11 branches; hair 1 with 4–5; 3 with 5–8; 13 with 3–7. Mesothoracic hair 1 stellate, with 6–10 branches; 13 small, stellate, with 6–12. Metathoracic hair 1 stellate, with 10–13 branches; 7 with 5–9 normal branches (fig. 13). Abdominal integument pilose simple or branched. Many stellate hairs present. Dorso-lateral hair of abdominal segment I and II with 2–3 branches; lateral hair of I–II with 1–2, of III–VI with 2–3. Hair 2 of III–VII elongate, stellate; on III with 5–6 branches; on IV and V with 3–5; on VI and VII with 2–4. Comb scales 50–72 in number (fig. 8); broad and scalelike, not appreciably tapered apically, with a conspicuous uneven lateral and apical fringe, a medial heavier spicule nearly always apparent. Siphon pilose (quite distinct at 90x; hair tuft with 4–5 long branches, the tips extending beyond the siphon apex; pecten composed of 15–20 long teeth, each tooth larger than the previous one, 4–6 teeth beyond the siphon hair tuft, the apical 4–7 teeth simple, the remainder each with 1–3 ventral denticles, the apical 2–5 teeth out of line with the others, tip of apical tooth approximately on a level with siphon apex (usually is hard to see the ventral denticles unless siphon is strongly flattened). Anal plate pilose; *lh* with 2 equal branches (rarely 3).

The larvae of specimens from Mindanao (all from one larval collection; 8 associated skins examined) differed slightly from those described above in having the tubercle of the meso- and metathoracic pleural hair tufts slenderer, and fully as long as the sclerotized base of the hair tuft. Also, the apical pecten tooth nearly always extends one-fourth to one-half its length beyond the end of the siphon, and all the pecten teeth except the apical ones that are out of line possess ventral denticles, these denticles are more prominent, and sometimes a small one occurs distad to the large one.

Considerable variation occurs in this larva, particularly in regards to the size and number of the branches of the stellate hairs, and in the amount and number of branches of the pile.

PUPA. Briefly described by Baisas (1946).

HABITAT. The larva is commonly found in the water collected in rock holes in and along the stream beds of forested streams. The rock pools may be small or large, and in shade or sun. Two records were taken of the larvae occurring in hollows on roots or fallen logs along stream beds. Collections of this species were made in all of the months from January to September.

REMARKS. The type series (exclusive of the adult of the holotype; the male genitalia was included however) was kindly loaned to the U. S. N. M. by Mr. Baisas for my examination. Unfortunately, all of the adult specimens were destroyed in transit. However, the male genitalia and the larval and pupal skins of the type series were undamaged, and with these the material described here compares well except that the anal gills of the types are somewhat shorter and more rounded apically.

Some variation was noted in the material studied. The color of the

upright forked scales of the female varied occasionally, being sometimes either mixed dark and pale, or nearly all pale. The submedian scutal lines are occasionally unbroken on one or both sides. Occasionally, the outwardly curved portion of the submedian line and the anterior end of the lateral line meet, as described by Banks for *rizali*. In several female specimens from Mindanao, a few median pale scales were seen on the palpi as described for *rizali*. Only once was a female specimen (from Samar) seen in which all of the abdominal tergite bands, except VIII, were medially broken, and these were only narrowly so. Female specimens from Leyte and Samar were quite uniform in having well-developed white basal bands on the tergites, whereas those from Mindanao generally had these bands reduced and occasionally even broken.

DISTRIBUTION. Known only from the Philippines. *Specimens examined*, U. S. N. M. (10 males, 32 females, 39 sets of adult-associated larval and pupal skins): Samar: Osmena (Lat. 11° 11.7′, Long. 125° 11.3′); Sohoton Springs, on Basey River. Mindanao: San Ramon, Zamboanga Province (J. L. Laffoon, L. E. Rozeboom, D. R. Johnson, E. S. Zolik, K. L. Knight). A. N. S. P. (10 males, 21 females, 9 larvae, 3 sets of assoc. larval and pupal skins): Leyte: Lagolago (near Baybay), Dagami (mt. stream), Samar: Osmena (H. R. Roberts).

Records from the literature. Luzon: Upper Molawin Creek, Los Banos Agr. Coll., Laguna Province (Baisas, 1946).

Aedes (Finlaya) burgosi Baisas, 1946

1946. *Aedes* (*Finlaya*) *burgosi* Baisas, Phil. Mon. Bull. Bur. Health 22: 27 (males, females, larvae, pupae). TYPE-LOC.: Philippines. Mindanao Island: Titunod Creek in Kolambugan, Lanao[8] (Guinto). TYPE: Male (holotype), nonexistent. Paratypes in the Philippine Bureau of Science and in the U.S.N.M.

ADULT. Mr. Baisas kindly made a loan of the holotype (the genitalia mount was not included, however), allotype, 5 paratypes, 1 male genitalia mount (of a paratype), and 2 larvae to the U. S. N. M. for use in this study. Unfortunately all of the adult specimens (except the thoracic capsule of 2 paratypes) were destroyed in transit.

From the type description and from an examination of the thorax of the 2 paratypes, this species is not separable from *abadsantosi* on adult external characters. The male genitalia differ, however, in having 12–30 bristles on each lobe of the ninth tergite. The ninth sternite usually bears only 2 bristles . In all other characters the genitalia are apparently identical with those of *abadsantosi*.

The 2 larval specimens sent by Mr. Baisas differ in several respects from the larva of *abadsantosi;* and also, are somewhat different from one another. One larva (R112-m) has the following distinctive characters from *abadsantosi:* head hair 17 with 6–9 branches; hair 18 with 5–6; mesothoracic hair 1 with 11; metathoracic hair 1 with 14–16; hair 2 of abdominal segment III with 7–9, of IV with 5–7, of V with 5, and of VI with 5; pentad hair 1 with 6, and 5 with 5; and the pecten teeth all in a

[8]Titunod Creek, Kolambugan, is given by the Gazetteer to Maps of the Philippine Islands, July, 1944, 2d Ed. (Army Map Service, U. S. War Dept.) as being in Misamis Occidental Province, Mindanao, which is some distance removed from Lanao.

line. The other larva (R112-k) differs as follows: head hair 17 with 8–11 branches; hair 18 with 7–9; mesothoracic hair 1 with 13–15; metathoracic hair 1 with 21; hair 2 of abdominal segment III with 11, of IV with 9, of V with 9–10, and of VI with 9; pentad hair 1 with 11, and 5 with 6; comb teeth longer and slenderer, a long distinct apical spine, and all of the fringe elements lateral; the teeth along the posterior margin of the anal plate very long; and, all of the pecten teeth in line except the last 2, which are dorsad to the line.

Whether or not the 2 larvae described above are cospecific will have to await the study of associated material. Until such material is available the larva of ***burgosi*** is considered to differ from ***abadsantosi*** on the greater number of branches of some of the hairs, and on the pecten not having any of the teeth distinctly out of line ventrally.

Baisas (1946) considered a series of specimens with associated larval and pupal skins from Mt. Apo, Davao, Mindanao (H. Hoogstraal) to be ***burgosi***. The male genitalia (2 males) of these differed from the type series of ***burgosi***, however, in having only 9–11 bristles on each lobe of the ninth tergite and in having 3 bristles on the ninth sternite (a scale was also present here in one specimen). I have not seen the larvae of this series, so cannot say how they compare with the 2 specimens of the type series described above.

If the Mt. Apo series is considered to be ***burgosi***, the range of the number of hairs occurring on the ninth tergite will be enlarged sufficiently (9–30) so as to overlap the range for ***abadsantosi*** (4–10), thus making the distinction between them on this character of dubious value.

PUPA. Described by Baisas (1946) from specimens of the Mt. Apo series.

DISTRIBUTION. Known definitely only from the type series.

Aedes (Finlaya) rizali (Banks), 1906

1906. *Culex rizali* Banks, Phil. Jour. Sci. 1: 999 (2 females). TYPE-LOC.: Philippines. Negros Island: Volcano Canlaon, Mt. Siya-Siya, at altitude of 760 meters, Negros Occidental Province (Banks). TYPE: Female (holotype), formerly was in Ent. Coll., Bur. Sci., Manila; now destroyed.
1922. *Aedes* (*Finlaya*) *rizali* Banks. Edwards, Ind. Jour. Med. Res. 10: 466.

ADULT. Not seen. By reference to the type description, this species apparently differs from *saxicola* as follows: *Male.*—Unknown. *Female.*—Wing 4 mm. in length *Apn* with a small oblong patch of golden-yellow scales (no reference made in description to *ppn* or to the scaling of the pleuron). Median scutal line extending halfway across the prescutellar bare space, not forked posteriorly; the submedian line broken at the scutal angle and connecting laterally with the line over the wing base. Tergites dorsally dark except for VI–VIII where the baso-lateral white spots extent slightly onto the margin of the dorsum. Banks described the pale areas of the femora as being "golden-brown," as opposed to the dark portions which he called "dark-brown"; however, the location of these paler areas coincides with the femoral white areas of *saxicola*. The tibiae are described as being all dark.

LARVA. Unknown.

HABITAT. The two females that made up the type series were taken in the act of biting.

REMARKS. This species has apparently not been retaken since Banks' type series was collected, nor have any additional notes ever been published on the type. Baisas (1946) states that the types of *rizali* were destroyed during the war.

This species is undoubtedly very closely related to *abadsantosi* and *burgosi*, the only significant difference apparent from the type descriptions being the complete or nearly complete tergal bands of the latter two (always complete on VIII). The extent of the tergal markings is subject to so much variation in the *chrysolineatus* group that it is even possible that this character does not offer a valid distinction. Consequently, until material is again collected from the type locality of *rizali* its exact status will probably remain undetermined. With only the type description to go on, it is also not separable from *jugraensis*.

I have examined the novotype material (only male genitalia and larval and pupal skins, as the adults were destroyed in shipment) designated for *rizali* by Baisas (1946), and it is cospecific with the species treated in this paper as *saxicola*.

Aedes (Finlaya) sherki, new species

ADULT. Similar to *saxicola*, but differing chiefly as follows: *Male.*—Wing approximately 2.7–3.4 mm. in length. Palpus dark, a few pale scales over the joint between III–IV. Median scutal line extends posteriorly nearly across the prescutellar area, not forked posteriorly; the submedian line is usually broken at the level of the scutal angle (even when not broken a division of the line usually bends briefly antero-laterally along the angle); the line over the wing base anteriorly nearly connecting at the scutal angle with the outcurved portion of the submedian line. *Apn* with a few narrowed yellowish scales above, broad creamy below; *ppn* sparesly covered with narrow-curved yellowish scales, some of the posterior scales may be broadened. Anterior surface of mid femur dark. Fore and mid tibiae with a pale posterior line along whole length, a short basal white area anteriorly on the mid tibia, a baso-ventral pale area on the hind tibia. Fore and mid tarsi sometimes with a small basal patch of white scales on III; hind tarsus with the first four segments basally banded. Tergites with complete broad basal white bands on III–VII, sometimes the bands narrowed dorsally, and with the dorsal portion separated from the dorso-lateral spot on III. *Genitalia:* Apparently identical to that of *abadsantosi* (see fig. 2) except that the ninth tergite lobes each bear 11–14 bristles.

Female.—Palpus with apex ringed with white scales. Tergites II–VI dark dorsally, or with a small medio-basal creamy patch on one or more of the segments, VII with the baso-lateral white spots extending prominently onto the dorsum; VIII with a complete basal white band.

LARVA. This larva is apparently not distinguishable from that of *abadsantosi* (see figs. 8 and 13). As with that species, considerable variation occurs in the size and the number of branches of the hairs, and in the amount of pilosity.

The six specimens from the collection containing the holotype (L. E. Rozeboom) are closely similar to that of the ***abadsantosi*** material from Leyte-Samar, except that the body pilosity is not as prominent and the pile on the siphon is hardly visible at 90x. Also, in most of the specimens the pecten teeth are somewhat smaller, with the apical tooth extending distinctly beyond the siphon apex.

The remainder of the larval specimens are similar to the Leyte-Samar ***abadsantosi*** material in having the body pilosity heavy and that on the siphon noticeably distinct at 90x, but differ in having the siphon and anal plate darkly pigmented, the pecten teeth with prominent and numerous denticles (usually first 2 teeth distad of hair tuft each with a denticle) and in having the apical pecten tooth usually extending distinctly beyond the siphon apex.

Only one specimen of the larval series for ***sherki*** exhibited sufficient production of the meso- and metathoracic hair tuft tubercle to be confused with the larval series of ***abadsantosi*** from Mindanao.

TYPES. ***Holotype: Male*** (1162.4) with associated larval and pupal skins (U. S. N. M. Cat. 58370), Baguio, City of Baguio Province, Luzon Island, Philippines, August 10, 1945 (L. E. Rozeboom, reared from small rock pool in rocky cool stream. ***Paratypes:*** Four males, 5 females 5 sets of associated larval and pupal skins, same data as for holotype; 2 females, Baguio, Luzon, June 12, 1945 (K. V. Krombein), reared from rock pool; 5 males, 14 females, 5 larval skins, Baguio, Luzon, August-September, 1945 (S. E. Shields), reared from a cardboard container, a can, and a rock pool; 2 males, 2 females, Baguio, Luzon, May, 1945 (A. B. Gurney and S. Soltys), from a forest stream; 10 males, 10 females, Park Circle, Baguio, Luzon, May, 1945 (J. C. Franclemont), from rock hole containing pine needles.

The series collected by Mr. Franclemont contains, in addition to the paratypes, 38 adults and 12 larva (Cornell University Collection).

Paratypes are deposited in the U. S. N. M., Academy of Natural Sciences of Philadelphia, British Museum (Natural History), Cornell University, and the Philippine Bureau of Health.

REMARKS. The adult of this species differs from all the other members of this group in having the combination of a basal white patch or band on segment IV of the hind tarsi, and in having the mid scutal line unforked posteriorly.

The two types of larvae described are probably only natural variant forms. No definite character for the separation of the larva of ***abadsantosi*** and the larva of this species was found. All characters examined seemed to show sufficient intergradation to render them useless for positive identification. It is true that the apical pecten tooth in ***sherki*** generally exceeds the siphon apex by one-fourth to one-half of its length, whereas it rarely does so in ***abadsantosi***.

This species is dedicated to Sgt. Herman D. Sherk, a tireless collector in the 423rd Malaria Survey Unit, who aided Dr. A. B. Gurney in making a large collection of Pacific mosquitoes.

Aedes (Finlaya) jugraensis (Leicester), 1908

1908. *Helecocteomyia jugraensis* Leicester, Cul. Malaya, p. 109 (male, female). TYPE-LOC.: Malaya. Jugra (Leicester). TYPE: Male, female, (cotypes), not in existence.

1922. *Aedes* (*Finlaya*) *jugraensis* Leicester. Edwards, Ind. Jour. Med. Res. 10: 466.

ADULT. Differs from *saxicola* as follows: *Male.*—Median scutal line extends onto the prescutellar bare space, nor forked posteriorly; anterior portion of submedian line absent or represented only by scattered scales. *Apn* with broad white scales; *ppn* with narrow scales. Prealar scale patch continuous with the dorsal sternopleural scale patch. Fore femur with a small creamy patch on the upper surface of the apex (this is according to Leicester; I failed to check this on the specimens). Tergites with the baso-lateral spots extended onto the dorsum and nearly forming complete bands on some segments. *Genitalia:* No information.

Female.—Whether or not the torus is scaled was unfortunately not noted. Tergites dark dorsally.

LARVA. No specimens have been seen, but from the description by Edwards and Givens (1928) and Edwards (Barraud, 1934) it apparently differs from *saxicola* as follows: Antenna with a small 2-branched hair placed a little beyond the middle. The base of the meso- and metathoracic pleural hair tufts each with a "rather long spine." (Metathoracic hair 7 as in *saxicola*). Abdominal lateral hairs triple on III–V, double on VI. Comb consisting of a patch of about 20 simple sharp-pointed teeth. Siphon index rather under 2. Pecten of 12–14 teeth, each with one large and several small denticles, the teeth forming a regular close-set row extending half the length of the siphon, no simple teeth apically (no mention is made whether there are any pecten teeth beyond the siphon hair tuft). (*lh* single).

HABITAT. The larva has been collected in fallen forest leaves, where it has been found in association with *Zeugnomyia gracilis* Leicester and *Uranotaenia obscura* Edwards (Edwards and Givens, 1928).

REMARKS. I was unable to find the type of this species in the British Museum, and since according to Mr. J. A. Reid, Institute for Medical Research, Kuala Lumpur, Malaya (in personal communication) there are no Leicester types at Kuala Lumpur, the types are apparently non-existent.

With present information, the adult of *jugraensis* cannot be separated from that of *rizali*.

DISTRIBUTION. *Specimens examined*, Brit. Mus. (1 male, 5 females): *Malaya*. Singapore, Ulu Gombak.

Aedes (Finlaya) sp., near **saxicola**

Fig. 7

There are four larval specimens from Palawan Island, Philippines in the U. S. N. M., that represent a previously unrecorded Philippine species. The larva is closely related to that of *saxicola* and is accordingly included here. Three of these specimens were collected (Oct.,

1945) from a streambed boulder depression and were submitted by Capt. Harry Hoogstraal of the 19th Medical General Laboratory –U. S. Army). The other specimen was collected in a rock hole on the Balsahan River (June, 1945) by J. L. Laffoon.

LARVA (fig. 7). Similar to *saxicola*, but differing chiefly as follows: Head hair 17 with 5–8 branches; 18 with 3–4. Prothoracic 0 hair larger, stellate; hair 1 with 4–7 branches; hair 3 with 7–9. Mesothoracic hair 1 with 8–9 branches; hair 13 a large stellate tuft of about 13–22 slender long frayed branches. Metathoracic hair 1 with 11–14 branches; hair 13 a large stellate tuft of about 12 slender long frayed branches. Abdominal integument finely pilose. Prominent stellate hairs present on all segments (particularly hairs 1 and 2). Dorso-lateral hair of I–II with 3–4 branches; lateral hair of I–II with 2–3 branches, of III–VI with 3–4 –occasionally 2). Hair 2 of III–VI stellate, with 4–6 elongate branches. Pentad hair 1 with 2–5 branches, 3 with 8–10, 5 with 4–5.

REMARKS. The differences between this larva and that of *saxicola* apparently consist entirely of the possession of more heavily branched hairs. Although these differences are very great, there are apparently no real structural differences. Consequently, this larva may represent only a form of *saxicola*, rather than a new species.

Aedes spp., near **abadsantosi**

In the British Museum collection there is a female specimen from the Philippines that possibly represents an unknown species. It closely resembles *abadsantosi* except that the anterior portion of the postspiracular scale patch consists of narrow yellowish scales and does not extend to the ventral margin of the spiracle. All of the abdominal tergites are dorsally dark except for a complete basal band on VIII. The specimen has the following data: Mt. Mupo, Dansalan (Mindanao); 28. III. 1920 (Dr. A. Moore).

In the collection of the Acad. of Natural Sciences of Philadelphia, there is a female specimen, Lagolago, Leyte (H. R. Roberts), with the postspiracular scales similar to those of the above specimen but differing in having the tergites with complete basal bands.

Also, in the U. S. National Museum there is a male specimen, with associated larval and pupal skins, which cannot be separated from *abadsantosi* except on male genitalic characters. The claspette blade is slender and tubular instead of being laterally flattened (this is utterly unlike anything known in this group), and there are 11–13 hairs on each of the ninth tergite lobes. This specimen must represent a distinct species but because of the lack of material, it is not named here. The data for this specimen is: San Ramon, Mindanao (K. L. Knight and J. L. Lafoon), reared from rock hole in hill stream, Sept. 17, 1945.

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A GENERIC REVISION OF THE ICHNEUMON-FLIES OF THE TRIBE OPHIONINI, by R. A. CUSHMAN. Proceedings of the United States National Museum, Vol. 96, No. 3206, pages 417–482, plates 49–56, 1947.

The author indicates in his opening paragraph that a projected revision of *Ophion* disclosed inconsistencies of the older classification which necessitated a wider study of the tribe and led to the present generic revision. During his study he found a number of characters not previously employed, hence we may conclude that his revised classification represents a more thorough analysis of the group and a more dependable and practical arrangement than has previously been available. It is unfortunate that material of all genera was not available, but this is a limitation that must often be faced in dealing with such widespread groups of insects.

The article includes a key to the tribes of Ophioninae and a key to the genera of Ophionini. Some new combinations are established and several new genera and species are described but the species making up the various genera are not treated in full—in short, the title "Generic Revision" is accurate. The plates are made up of excellent drawings of structural details. While the article will be of little practical value for the identification of specimens it is an important contribution to the basic classification of the insects.—A. W. L.

A NEW GENUS AND SPECIES OF PSYLLIIDAE FROM MEXICO

(Homoptera)

JOHN S. CALDWELL,
Circleville, Ohio

In 1913[1] Crawford erected the genus *Paurocephala* for the Philippine species *psylloptera*, and later in 1914[2] described *magnifrons* a Mexican species in this genus. In 1919[3] after describing *Paurocephala conigra* from the Molaccas Crawford states that *conigra* is closely related to *magnifrons* and intimates that the two forms possibly constitute a new genus. I am not familiar with *conigra* and have not included it in this work. The genus *Trigonon* Crawford was set up in 1920[4] to receive two South Pacific forms, the type *Heteropsylla longicornis* Crawf. and *T. pacificum* Crawf. Subsequently in 1925[5] *Psylla erythrinae* Lizer, a South American species, was placed in *Trigonon*. There is no doubt that *magnifrons* Crawf. and *erythrinae* Lizer are congeneric even though each have been placed in separate genera.

I have examined specimens of *longicornis* and *pacificum* Crawford, loaned to me through the courtesy of the proper authorities of the U. S. National Museum upon the recommendation of Miss Louise M. Russell of the U. S. Department of Agriculture, and find *longicornis* to be generically distinct from *erythrinae* and *magnifrons*; nor can these two American species be included in *Paurocephala* as represented by the type species. The forms in the Western Hemisphere, with one exception, are without a genus consequently I propose a new genus to include *magnifrons* Crawford and *erythrinae* Lizer, and a new species from Mexico. This leaves *Paurocephala fremontiae* Klyver the dubious representative of *Paurocephala* in the new world.

Neopsyllia new gen.

Head broader than thorax. Vertex twice as broad as long, evenly rounded downward and under, narrowed to a prominent frons. Eyes prominent; lateral ocelli scarcely elevated above plane of vertex. Clypeus rounded, prominent. Genae greatly swollen. Antennae about as long as entire insect. Thorax little arched; pronotum declivent. Forewings elongate; basal costal margin thin, plate-like; pterostigma long, narrow; first marginal cell approximately twice the size of second. Apex of hind tibiae with one spur on out side and four within, two of the four closely appressed. Proctiger of male without caudal flaps.

Differing from either *Trigonon* Crawf. or *Paurocephala* Crawf. by the broad, very smooth vertex narrowed and evenly rounded to the

[1]1913. Philip. Jr. Sci., 8: 293–294.
[2]1914. U. S. N. M. Bul. 85: 42–43.
[3]1919. Philip. Jr. Sci., 15: 151–152.
[4]1920. Philip. Jr. Sci., 17: 354–355.
[5]1925. Broteria Ser. Zoo., 22: 18–19.

frons. Separated from *Heteropsylla* Crawf. by the vertex, frons, and genae forming a smooth surface and by the frons being placed before the genae. The forewings also lack the very broad pterostigma characteristic of *Heteropsylla*.

Type: *Neopsyllia amabilis* n. sp.

Neopsyllia amabilis n. sp.

Total length of male 3.4 mm., female 3.9 mm.; forewing of male 2.8 mm., female 3.1 mm. Face orange-yellow with a transverse black stripe between eyes. Antennae yellow on four basal segments, remainder black. Pronotum marked with black as follows; a median dash on anterior margin and a transverse line near posterior margin interrupted medially. Prescutum with a black median line and an ovate mark on either side of the line. Scutum sometimes with a broad orange stripe far latrad on either side. Abdomen yellow; tergites margined and spotted with black; an irregular black line present on either side in ventral aspect. Forewings hyaline, slightly yellowed apically; four indistinct dark marginal dashes present apically.

Proctiger of male quadrate in lateral aspect. Genital capsule broadly notched on ventro-anterior margin. Forceps as long as proctiger, broad; apices narrow, convergent, each terminated by a blunt tooth; apical third of anterior margins bearing very heavy spines. Female genital segment as long as rest of abdomen; dorsal valve narrowed in apical third to styliform apex.

Male *holotype*, five male and five female *paratypes* from Jalapa, Veracruz, 10–31–45, K. 270, (DeLong, Elliott, Hershberger, & Shaw). Female *allotype* from Jacala, Hidalgo, 8–13–36, (Ball) is in the U. S. National Museum. I have also seen one female in poor condition intercepted by the Bureau of Entomology & Plant Quarantine with the following date: 2–4–47, Chilpancingo, Guerrero.

A PLEA FOR BREVITY—AND SANITY—IN ZOOLOGICAL NOMENCLATURE, by J. C. Faure. Journal of the Entomological Society of South Africa, Vol. IX, pp. 39–44, 1946.

This short article, which has reached the editor as an author's reprint, brings up the perennial difficulty of unwieldy scientific names. *Brachyuropushkydermatogammarus* remains in the reviewer's memory from years ago as a gem to be ridiculed before his classes, but the author cites other such names from the work of Dybowski, published in 1926, as a basis for his very lucid plea for practical limitations on the coining of scientific names. One is forced to agree with him that descriptiveness is of little if any value in our scientific nomenclature; certainly an adequate description cannot be encompassed by one word, whatever its length. Shortness and pronounceability, appropriateness and descriptiveness as far as the latter is possible, and sufficient difference from existing names to avoid confusion are the principal points emphasized. The author suggests that it may be wise for the International Rules to contain a limitation of fifteen letters for newly proposed scientific names. Probably the good sense of most taxonomists makes a rule unnecessary, but workers on the Crustacea who may run afoul of Dybowsky's creations may find it desirable.—A. W. L.

SPORADIC POLYEMBRYONY IN GRASSHOPPER EGGS

E. H. SLIFER AND A. SHULOW,
Department of Zoology, State University of Iowa,
Iowa City, Iowa,
and the
Hebrew University, Jerusalem, Palestine

The finding of more than one embryo in a grasshopper egg is a rare event (Evans, 1937) and when, through correspondence, it was discovered that the authors of the present paper had both found eggs which contained extra embryos it was decided to combine the results in a single report.

The eggs of *Dociostaurus maroccanus* were obtained and studied by Shulow in Palestine and those of *Melanoplus differentialis* were secured from the grasshopper colony maintained in the Zoology Department at the State University of Iowa and were examined by Slifer.

Dociostaurus maroccanus

During extensive investigations (Bodenheimer and Shulow) on the eggs of *Dociostaurus maroccanus* two were found which contained more than one embryo. Externally these eggs were normal in size and shape and the unusual internal conditions were discovered only after the eggs had been fixed and then stained with borax carmine. In this respect the eggs differed from those of *Carausius morosus*, *Menexenus semiarmatus*, *Baculum* (*Clitumnus*) *artemis* and *Clonopsis gallica* described by Cappe de Baillon (1927, 1928, 1937). In these phasmid eggs with twin embryos the micropylar apparatus on the chorion was double and the operculum, which is ordinarily present, was missing.

The normal embryology of *Dociostaurus maroccanus* is essentially like that of *Melanoplus* (Slifer, 1932) and *Locusta* (Roonwal, 1937). The early germ band is a flattened structure, pear-shaped in outline, and is located close to the posterior or micropylar end of the egg. The caudal end of the embryo broadens and grows in length while the protocephalic region increases in size. This is followed by segmentation and the appearance of the appendages. During these stages the

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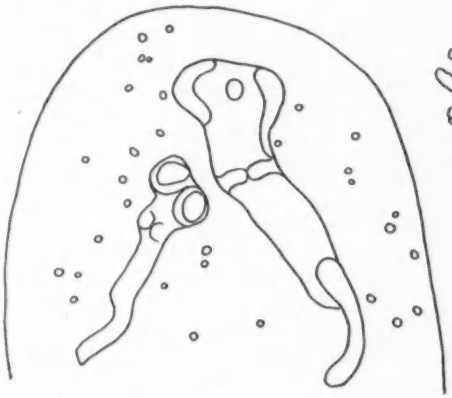
EXPLANATION OF PLATE I

FIG. 1. *Dociostaurus maroccanus*. Posterior end of egg with three embryos. The cephalic end of each embryo faces the micropylar end of the egg. Largest embryo 0.65 mm. in length. FIG. 2. *Dociostaurus maroccanus*. Two embryos from one egg. Total length of both embryos 0.43 mm. Fig. 3. *Melanoplus differentialis*. Twin male embryos from one egg. Before removal from egg dorsal surfaces were in closer contact and heads and abdomens were not flexed backwards. Length of embryos about 2 mm. FIG. 4. Same embryos as Fig. 3, opposite surface. FIG. 5. *Melanoplus differentialis*. Twin embryos from one egg. Larger embryo apparently a female, sex of other not determined. Length of larger embryo about 3.5 mm. FIG. 6. Same embryos as Fig. 5, opposite surface.



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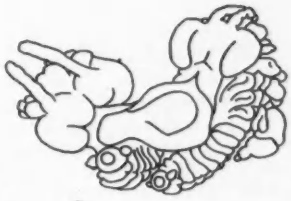

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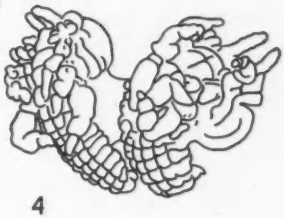

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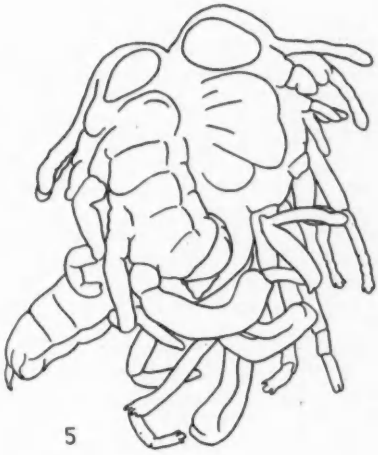

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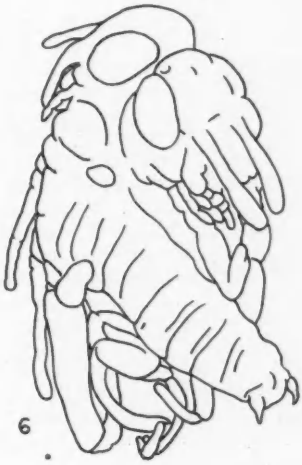

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embryo is located on the ventral or concave surface of the egg with its head close to the micropylar end while its abdomen extends anteriorly along the ventral surface of the egg.

The posterior end of one of the eggs which contained extra embryos is shown in fig. 1. Two of the embryos in this egg were well-developed and were separated by a considerable distance while a third embryo, retarded and less normal in appearance, lay close to the caudal end of the larger one of these two. This egg was laid in the laboratory and had been kept at 100% R. H. and 27° C. When fixed (Aug. 8, 1946) it was about three months old.

The other unusual egg, fixed July 18, 1945, was taken from a pod laid in the field about two months previously and contained two embryos (fig. 2) younger than those in the first egg. The larger and better-developed embryo was about 0.2 mm. long. The smaller one was quite abnormal in shape.

Melanoplus differentialis

During the past twenty years hundreds of thousands of eggs of *Melanoplus differentialis* have been examined and dissected by one of us (Slifer). Large numbers of abnormal embryos of many different kinds have been found, particularly in some of the highly inbred stocks, but only two eggs which contained complete or nearly complete twin embryos have been seen. These were both found in living eggs from which the chorion had been removed with sodium hypochlorite (Slifer, 1945).

The first egg, found Oct. 20, 1944, was allowed to continue its development for three weeks longer at 25° C. When first seen the embryos were located at the posterior end of the egg with their heads already directed anteriorly. Both seemed to be nearly complete except for their dorsal regions. One faced the convex and one the concave surface of the egg. Their lateral body walls showed regular, rhythmic contractions as is usual at this stage. During the succeeding three weeks the embryos grew in a surprisingly normal manner. Much, but not all, of the yolk was engulfed, the appendages elongated and the hind femora acquired the brown pigment spots characteristic of embryos which are due to hatch about a week later.

When it became apparent that development had slowed down and was about to stop the embryos, still alive, were dissected out of the egg and fixed (Figs. 5 and 6). They were then found to be united by their anterior dorsal surfaces. One embryo, except for the region where it was joined to its twin, was entirely normal in appearance but the abdomen of the other was shortened and its segments telescoped together. Apparently the second embryo had failed to secure enough yolk to fill its midgut. The tenth abdominal sternum of the larger embryo appeared to be that of a female (Nelsen, 1931) but the sex of the other embryo could not be determined.

The second egg with twin embryos was found Feb. 23, 1945, and was opened in Ringer's solution and the contents fixed at once. The embryos, still attached, are shown in figs. 3 and 4. While still in the egg both embryos were back to back, their lateral walls were in contact and their heads were not far from the posterior end of the egg. When

placed in the fixative their heads and abdomens were flexed dorsally and the lateral body walls on one side broke apart. Both of these embryos were perfect externally, of the same size and at the same stage of development. The well-developed appendages on the tenth abdominal sterna showed them both to be males (Nelsen, 1931).

SUMMARY

Several eggs which contained two or more embryos have been found in *Dociostaurus maroccanus* and *Melanoplus differentialis*. Polyembryony, in these species, is of the type described by Patterson (1927) as accidental or sporadic.

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PAPÈIS AVULSOS DO DEPARTAMENTO DE ZOOLOGIA, VOL. VII. Secretaria da Agricultura, Indùstria e Comercio, Sao Paulo, Brasil, 1947.

This volume of *Papèis avulsos* is composed of twenty-five articles, most of them on arthropods. Two are of more general interest: *Nota sobre Nomenclatura Zoologica* by AFRANIO DO AMARAL and *Notas de Nomenclatura* I by LAURO TRAVASSOS Filho. Others include an article on Tipulidae from Sao Paulo by CHARLES P. ALEXANDER, several on Diptera by MESSIAS CARRERA, several on Coleoptera by R. L. ARAUJO and E. NAVAJAS and one on Hesperiidae—a faunal list—by KENNETH J. HAYWARD. BENEDICTO A. M. and HELIA E. M. SOARES contribute nine articles on spiders and harvestmen. The reviewer notes a considerable number of descriptions of new species.—A. W. L.

NEW TRICHOPTERA FROM PUERTO RICO

D. G. DENNING,
University of Wyoming

Very few Trichoptera have as yet been recorded from the West Indies; still fewer are known from Puerto Rico. It was with considerable interest that a collection of Trichoptera from Puerto Rico was examined and found to contain a number of species, five of which were new. I have been informed by Dr. H. D. Pratt who collected these specimens that material secured from Lake Tortuguero, which is in Vega Baja township, are from the only large fresh water lake in Puerto Rico and that it is located practically at sea level; specimens from El Yunque are from the best known high mountain in Puerto Rico and were collected at about twenty-two hundred feet elevation; those collected at Luquillo are from "roaring streams coming out of the high tropical rain forest" and were taken at approximately five hundred feet elevation. I would like to express my gratitude to Dr. H. D. Pratt of the U. S. Public Health Service for collecting these specimens.

Unless indicated otherwise types of these new species are in the author's collection at the University of Wyoming.

Oecetis pratti n. sp.

This species can be readily separated from other described species of the genus by the long slender, apically enlarged tenth tergite, the fingerlike claspers when viewed laterally and the peculiar aedeagus.

Male.—Length 9 mm. General characteristics, color and size resembles *Oecetis inconspicua* Wlk. Genitalia as in fig. 1. Ninth segment widest in the middle and with a rather dense brush of setae along ventral margin. Tenth tergite slender, gradually enlarged apically to a rounded knob-like apex when viewed from either lateral or dorsal aspect; a few short scattered setae apically; directed ventrad beyond cerci, dorsal view as in fig. 1A. Cerci flattened, about same width throughout, rounded apically. Claspers viewed laterally, digitate, basal portion somewhat angulate; mesal portion projected mesad as a wide flat flange almost to aedeagus, its distal margin studded with short setae. Aedeagus tubular, robust, distal evaginated portion semimembranous, turned abruptly dorsad into a triangular apex. When seen from ventral aspect a pair of slender acute heavily sclerotized teeth are discernable at base of the triangular apical portion.

This species is named in honor of Dr. H. D. Pratt who collected not only this species but all the other species recorded herein.

Holotype, male.—El Yunque, Puerto Rico, May, 1945, H. D. Pratt.

Oecetis inconspicua (Walker)

Vega Baja, Puerto Rico, March, 1944, H. D. Pratt, 2 males, 7 females. Lake Tortuguero, Puerto Rico, May 25, 1944, H. D. Pratt, 1 male.

Chimarra luquillo n. sp.

This beautifully colored species is a close relative of *Chimarra braconoides* (Wlk.) originally described from Santo Domingo. It can readily be separated from that species by the tenth tergite, the ventro-mesal portion of the ninth sternite and several other differences in the male genitalia.

I would like to express my appreciation to Mr. Nathan Banks for comparing this species with determined species in the Museum of Comparative Zoology and stating that it is distinct from other described species.

In both sexes the head, body, antennae and legs bright yellow, setae of the head and thorax yellow, spurs brownish. The fore wings blackish with a number of bright silver markings as shown in fig. 2. In the male the spur of the fore leg minute, the claws greatly modified, the inner quite similar in shape to the outer claw, but only about one-half its size, the outer claw, fig. 2A, almost as long as the last tarsal segment. In the female the claws are minute and unmodified.

Male.—Genitalia as in fig. 2B, and fig. 2C. Eighth tergite curved ventrad distally, lateral portion produced caudad to form an inverted V when seen from caudal apsect, ventro-distal lobes somewhat more heavily sclerotized than remainder and bearing a dense brush of minute blackish setae. Ninth segment with ventral portion wide, ventro-mesal projection directed caudad when viewed ventrally, fig. 2C, slightly upturned when viewed laterally; dorsally ninth tergite reduced to about one-tenth width of ninth sternite; lateral margin produced into an irregular finger-like process, inner ventral angle acute; ventrad to this the lateral margin is produced into a circular process bearing a few small setae. Claspers rather inconspicuous, somewhat circular when viewed ventrally, bearing a few small setae. Cercus obovate, bearing a few setae, situated on lateral aspect of ninth segment ventrad from base of tenth tergite. Tenth tergite with an attenuated dorsal angulation, lateral and ventral margins nearly straight forming an acute apex; when seen from dorsal aspect apical margin bifed, forming a deep triangular incision. Aedeagus in a sclerotized tubular process, which is incised ventrally to about one-half its length; membranous aedeagus projected caudad from this structure, internally two pairs black spines.

Female.—Very similar in coloration and general appearance to the male, but lacking such modifications as the claws of the forelegs that are present in the males.

Holotype, male.—Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt.

Allotype, female.—Same data as for Holotype.

Paratypes, 109 males, 47 females.—Same data as for Holotype.

Male and female paratypes are deposited in the Entomological collections of the University of Minnesota, the Illinois Natural History Survey and the Museum of Comparative Zoology.

Chimarra aterrima Hagen

Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt, 1 male, 1 female.

Cheumatopsyche protera n. sp.

This species differs radically from other described species. Of the known species it is probably one of the most generalized in the genus.

Male.—Length 6 mm. Wings brownish with a distinct white spot along margin of forewing where R_1 and R_2 joins margin. Spurs 1–4–4. Diagnostic characters apparently restricted to genitalia.

Genitalia as in fig. 3. Tenth tergite long, prominent, when viewed laterally gradually tapering toward distal margin and directed dorsad; lateral processes ovate, not raised dorsad appreciably, bearing a few small setae apically; dorso-lateral surface with a distinct fold with a group of strong setae directed cephalad; baso-mesal portion, viewed dorsally, fig. 3A, with a patch of irregularly placed, dense, flat setae. Claspers with basal segment about twice length of apical, apex considerably narrowed, fig. 3B; apical segment curved laterad but not quite touching one another, enlarged apically, apex acute, bearing several minute setae. Aedeagus with basal portion only slightly enlarged, viewed ventrally apical portion considerably enlarged, distal margin emarginate; apex not distinctly divided into apico-lateral lobes as so common in genus; internally a small heavily sclerotized process.

Female.—Length, coloration and other characters very similar to male; apparently diagnostic characters are available only in the genitalia.

Genitalia as in fig. 3C. As would be expected from the curious male genitalia the female eighth, ninth and tenth segments have likewise undergone a remarkable modification which is radically different from other described species. Mesal margins of eighth sternites separated by about one-half their width; when viewed from lateral aspect, ventro-distal corner attenuated caudo-ventrad. Eighth tergum not perceptibly divided from eight sternum; meso-distal margin with following modifications: a short distance dorsad of eighth sternum margin projected caudad as a large spine-like process and extended beyond as a ridge to which is attached a large flap-like process which extends caudad to opening of clasper receptacle, distal margin minutely serrate, its ventral plate-like projection with inner surface concave to probably aid in holding the clasper of the male as the apparent clasper groove is just below it on the ninth tergum, its dorsal margin inserted on eighth tergum, near base of insertion arise a dense brush of long flat setae; near mesal margin arises another dense brush of long flat setae. Ninth tergum, viewed dorsally fig. 3D, with distal margin irregular and bearing two rows of spines, mesal portion of dorsal surface with a tri-

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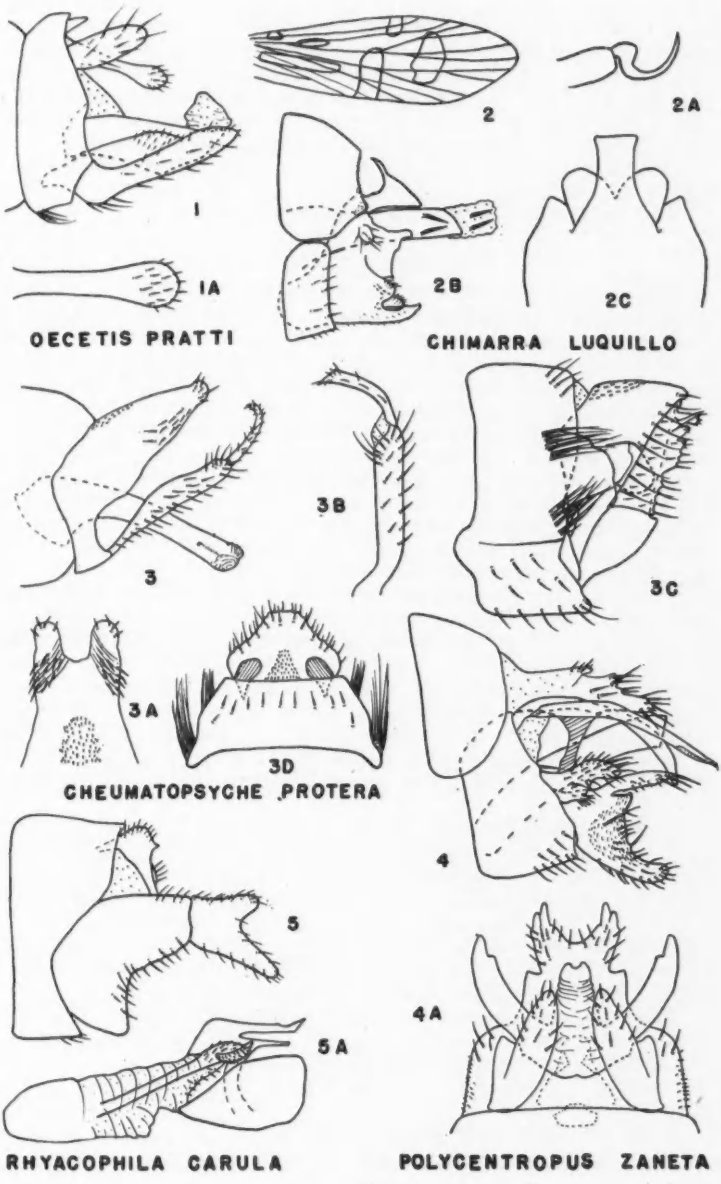
EXPLANATION OF PLATE I

FIG. 1. *Oecetis pratti*, male genitalia, lateral aspect; 1A, tenth tergite, dorsal aspect. FIG. 2. *Chimarra luquillo* fore wing; 2A, male outer claw, fore leg; 2B, male genitalia, lateral aspect; 2C, male genitalia, ventral aspect. FIG 3. *Cheumatopsyche protera*, male genitalia, lateral aspect; 3A, tenth tergite, dorsal aspect; 3B, claspers; 3C, female genitalia, lateral aspect; 3D, female genitalia, dorsal aspect. FIG. 4. *Polycentropus zaneta*, male genitalia, lateral aspect; 4A, female genitalia, ventral aspect. FIG. 5. *Rhyacophila carula*, male genitalia, lateral aspect; 5A, aedeagus.


1
2
2A
1A
2B
2C
OECETIS PRATTI
CHIMARRA LUQUILLO
3
3B
3C
3A
3D
CHEUMATOPSYCHE PROTERA
4
5
5A
4A
RHYACOPHILA CARULA
POLYCENTROPUS ZANETA

angular patch of minute, dense flattened setae; clasper receptacle very large, broadly circular, directed ventro-caudad beyond margin of tenth tergum when viewed laterally, margin slightly irregular and minutely serrate dorsally; internal surface presents a facet appearance; opening to clasper receptacle elongate oval. Plates of tenth tergum with distal margin very irregular, widened ventrally, its margin extending cephalad almost to edge of opening to clasper receptacle.

Holotype, male.—Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt.

Allotype, female.—Same data as for holotype.

Polycentropus zaneta n. sp.

This species can readily be distinguished from other described members of the genus by the claspers, the cerci, the curious tenth tergite and other details of the male genitalia.

Male.—Male genitalia as in fig. 4. Eighth segment with sclerites unmodified. Ninth sternite with ventral portion wider than dorsal portion, caudal margin irregular. Tenth tergite with basal portion semimembranous, dorsal margin very irregular and bearing a number of prominent spine-like setae; apical margin emarginate. Each cercus divided near base into two long sclerotized rods, curved gradually caudad and ventrad; outer cercus with apex tapering to a sharp point, a very lightly sclerotized area near apex, directed caudad beyond inner cercus; inner cercus with apex sub-acute; cerci bear no setae. Along meso-lateral margin of ninth sternite arises a prominent process directed caudad, bearing many small and large setae. Claspers large with many large setae, dorsal margin extended caudad as a finger-like process, its dorsal margin convex, its ventral margin minutely serrate, apex bearing several long setae; viewed from ventral aspect apex curved slightly laterad; the ventral lobe directed ventro-caudad, apex blunt, lateral surface concave, process with a number of large and small setae; inner mesal margins gradually divergent from base. Aedeagus tubular, only slightly curved, distal margin extends just beyond tenth tergite.

The head and portions of the appendages are missing from the holotype.

Female.—Genitalia as in fig. 4A. Lateral lobes long, narrow, gradually tapering at apex, widely separated at base; lateral margin produced into a distinct angulation. Dorsad to the lateral lobes is a plate with long, narrow, acute clasper-like projections directed gradually caudad and a lightly sclerotized medial plate emarginate at distal margin. The ano-vaginal opening is lined latero-ventrally with a pair of heavily sclerotized plates and a ventral lightly sclerotized concave plate. The bursa copulatrix circular, supports indistinct.

Holotype, male.—Luquillo, Puerto Rico, November, 1943, light trap, H. D. Pratt.

Allotype, female.—Same data as for holotype.

Paratypes, 1 male, 1 female.—Same data as for holotype.

Rhyacophila carula n. sp.

This species belongs to the *fenestra* Ross, *ledra* Ross section of the genus. It can readily be separated from these and other described

species of the genus by the lateral arms of the aedeagus, the claspers and other details of the male genitalia.

Male.—Length 9 mm. Genitalia as in fig. 5. Sternite of seventh segment with a small acute mesal projection. Tenth tergite narrow, incised apically down the meson its entire length, lateral lobes convex dorsally, distal margin with a small acute heavily sclerotized point. Basal margin of claspers broad, short, ventro-caudal inner surface deeply concave; apical segment short, distal margin incised to form a short blunt dorsal projection and a long gradually tapering ventral projection, inner surface of dorsal projection with abundant short brown setae, apical two-thirds of inner surface of ventral projection with sparsely scattered short brown setae. Aedeagus, fig. 5A, consists of a pair of lateral arms and a pair of thin ventral plates with sides flared dorsad, from ventral aspect these plates are fu ed along mesal margins and with a deep narrow incision along distal margin; the mesal portion is projected abruptly dorsad as a blade-like ridge divided into a dorsal arm, long, slender and acute apically, and a ventral arm which is shorter and narrower. Lateral arms in a membranous pocket from which they can apparently be extended, basal portion long and narrow, apical portion cup-shaped when viewed laterally, densely covered with short brown setae; from dorsal aspect apex widened, concave and with a striated appearance.

Female.—Length 9 mm. Similar in general appearance to male. Apical segments of abdomen tubular and tapering. Sixth sternite with a prominent, acute conical projection. Eighth sternite deeply incised.

Holotype, male.—Luquillo, Puerto Rico, November, 1943, light trap, H. D. Pratt.

Allotype, female.—Same data as for holotype.

A REVISION OF THE TRIBE SCAPHYTOPINI (Homoptera, Cicadellidae) IN AMERICA NORTH OF MEXICO, by Leon W. Hepner. The University of Kansas Science Bulletin, Vol. XXXI, part II, No. 16, pages 413–541, plates XXIII-XXIX, Nov. 1, 1947.

The study of more than twenty-five thousand specimens in the revision of a group containing seventy-three species should be an ample guaranty of the practical value of the work. In his opening historical sketch of the taxonomy of the group the author indicates several changes in generic usage, particularly the suppression of most of the genera described by Ball, a step for which his abundant material and careful study should be an adequate foundation.

The treatment is admirable for practical use. Genera and subgenera are described and provided with keys to the included species. Each species is described in detail and notes are included on the location of types, geographic distribution, host plants and comparison with other species. Bibliographic citations are limited to the original descriptions of species and synonyms, with a list of fifty-six titles at the end of the text.

With the exception of plate XXIII, which illustrates structural and genitalic characters in line cuts, the plates are unique. They are made up of half-tone *negative* figures of male and female genitalia. The author's technique of making these figures as photomicrographs directly on paper must be a very convenient method of securing records for study, once the apparatus is set up. Although the reviewer's experience with photomicrographs of genitalia leads him to prefer good drawings, these figures appear so clear in detail that they should be entirely adequate.—A. W. L.

THE NORTH AMERICAN GALL MIDGES OF THE TRIBES CATOTRICHINI AND CATOCHINI
(Diptera: Itonididae (Cecidomyiidae))

A. EARL PRITCHARD,[1]
University of California,
Berkeley

The classification of the gall midges of the tribes CATOTRICHINI and CATOCHINI was in a state of confusion prior to the work of Edwards (1938). At that time Edwards proposed these tribal concepts, erected two new genera, and redescribed a few of the species known to occur in the northern hemisphere. Two of the previously described genera were excluded from his revision because he believed that they properly belonged to the SCATOPSIDAE, and most of the types were not available to him for examination.

The present study constitutes a comprehensive review of all the species known to occur in North America. Thirteen species were described by Felt of which six are here considered valid; one species was described by Alexander. Most of these are considered rare, and nothing is known of their biology. Two species are noteworthy because of having been taken off snow in wintertime, and others have been captured only in the late fall or early spring.

The writer is grateful to Dr. R. D. Glasgow and Dr. C. C. Adams for the privilege of studying the types in the New York State Museum, to Mr. Nathan Banks for the privilege of studying the type in the Museum of Comparative Zoology, to Mr. C. F. W. Muesebeck and Dr. E. A. Chapin for the many courtesies extended in studying the types in the U. S. National Museum, and to Professor C. E. Mickel and Dr. S. W. Bromley for additional specimens.

Tribe **Catotrichini** Edwards

Catotrichini Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938.
Catotrichiariae Mani. Ind. Jour. Ent., 7: 191, 1946.

The CATOTRICHINI apparently comprise the most generalized members of the family ITONIDIDAE. The group resembles the LESTREMIINI and CATOCHINI in wing venation in that M_1 and M_2 are present, but it differs from both in that M_{3+4} arises from M rather than being free. This vein (Cu_1 of Edwards) is distinct from Cu_1 which, when present in the ITONIDIDAE always forms a branch of Cu near its middle. Although either M_{3+4} or Cu_1 may be found in the LESTREMIINAE, the two veins occur simultaneously in some of the more generalized ITONIDINAE. The flagellum of the CATOTRICHINI bears scattered bristles but no definite whorls, a condition that is otherwise found only in the genus *Anarete* (LESTREMIINI).

[1]Assistant Professor of Entomology and Assistant Entomologist in the Experiment Station.

The tribe contains but a single genus to which two North American and one Japanese species have been referred. The female is unknown.

Genus **Catotricha** Edwards

Catotricha Edwards. Proc. Roy Ent. Soc. Lond., 7 (ser. B): 102, 1938.

Genotype.—*Catocha americana* Felt, by original designation.

KEY TO SPECIES, NORTH AMERICAN MALES

1. Medial fork distinctly longer than stem; r-s less than three times length of r-m; ninth tergite very shallowly and broadly emarginate; disticlasper very long and slender with short internal projection proximally..... **americana**
   Medial fork distinctly shorter than stem; r-s about five times length of r-m; ninth tergite deeply and broadly emarginate; disticlasper short and broad, with slender internal projection..... **subobsoleta**

Catotricha americana (Felt)

Catocha americana Felt. Bull. N. Y. State Mus., 124: 309, 1908 (fig. antennal segment); Bull. N. Y. State Mus., 165: 130, 1913 (fig. adult, antennal segment).

Catotricha americana (Felt): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938 (fig. wing).

This species, known from a single male, has been adequately described and illustrated by Felt and Edwards.

Monotype.—Male, at the New York State Museum.

Specimen examined.—NEW HAMPSHIRE: one male, Franconia, A. T. Slosson. (monotype of *americana*).

Catotricha subobsoleta (Alexander)[1]

Catocha subobsoleta Alexander. Insec. Inscit. Mens., 12: 82, 1924.

Catotricha subobsoleta (Alexander): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938 (fig. wing, antennal segment, male genitalia).

The holotype male of this species has been adequately figured by Edwards. Three additional males were recently sent to the writer by Dr. S. W. Bromley.

Holotype.—Male (on cardpoint), in the U. S. National Museum.

Specimens examined.—OREGON: three males, Boyer, April 11, 1937. WASHINGTON: one male, Longmire Springs, June, 1917, H. G. Dyar (holotype of *subobsoleta*).

Tribe **Catochini** Edwards

Catochini Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 104, 1938.
Catochariae Mani. Ind. Journ. Ent., 7: 191, 1946.

The tribe CATOCHINI differs from the CATOTRICHINI and the LESTREMIINI in that the humeral cross-vein and the plical vein (An of Edwards) are absent. It further differs from the LESTREMIINI in having three, rather than two ocelli and by possessing sclerotized spermathecae in the female. The medial fork is shorter than the stem and the costa usually extends well beyond R_5.

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[1]The drawing of the male of *Hormosomyia oregonensis* Felt which was presented by Cole and Lovett (Proc. Calif. Acad. Sci., 11: 223, 1921) was based upon a misidentification, and the specimen figured actually represents *Catotricha subobsoleta* (Alex.).

Members of the CATOCHINI have been described from Europe, North America and India, but only the genus *Catocha* has been recognized outside North America except for *Catarete* which is known only from Europe.

KEY TO GENERA

1. Medial fork very uneven, the upper branch sigmoid; R_s short, joining costa just beyond middle of wing; costa extending very shortly beyond R_s; flagellar segments of both sexes short and broad, each with a pair of budlike sensoria ..... **Tritozyga**
   Medial fork with the bracnhes even; R_s extending well beyond middle of wing; costa extending well beyond R_s 2
2. Wings with macrotrichia; empodium as long as claws 3
   Wings without macrotrichia; empodium very short 4
3. Cu_2 strongly bent; R_s not reaching end of wing; flagellar segments of female without stems, each with a pair of bud-like sensoria; dorsal eye widely separated from lateral eyes ..... **Neocatocha**
   Cu_2 evenly curved; R_s reaching end of wing; flagellar segments pedicillate, with forked sensoria; eye bridge 2–3 facets wide ..... **Catocha**
4. R_s strongly arched distally, reaching wing tip ..... **Eucatocha**
   R_s gently curved, not reaching end of wing 5
5. R_s approximate to C, curved anteriorly; Cu_2 evenly curved; antennae of female 8 segmented ..... **Catarete**
   R_s widely separated from C, nearly straight; Cu_2 sigmoid; antenna of female 10 segmented ..... **Anocha**

Genus **Tritozyga** Loew

Tritozyga Loew. Monog. N. Amer. Dipt., 1: 178, 1862 (no species included; fig. wing); Skuse, Proc. Linn. Soc. N. S. Wales, 3: 143, 1889; Kieffer, Bull. Soc. Hist. Nat. Metz, (ser. 2) 8: 53, 1898; Kieffer, Ann. Soc. Ent. France, 69: 447, 1900; Felt, Jour. N. Y. Ent. Soc., 19: 32, 1911; Enderlein, Arch. Naturg., 77 (Bd. 1, Suppl. 3): 192, 1911; Felt, Bull. N. Y. State Mus., 165: 148, 1913; Kieffer, Gen. Insect., 152: 310, 1913; Edwards, Ent. Mon. Mag., 65: 10, 1929; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 1938.

Genotype.—*Tritozyga sackeni* Felt, the first species included, and by subsequent designation of Felt, 1911.

Edwards excluded from consideration the genus *Tritozyga*, stating that he strongly suspected it to belong properly to the SCATOPSIDAE. The wing venation is certainly different from that of any other itonidid, but Loew and Felt were quite correct in placing it in the ITONIDIDAE. *Tritozyga* differs from the scatopsids and agrees with the itonidids in having the eyes bare, the antennae with whorled bristles as well as a few scattered lateral bristles, the proximal end of M_{3+4} evanescent, the femora slender, and the tibiae not incrassate distally.

The configuration of the radius and costa in *Tritozyga* is rather similar to that of the LESTREMIINI except that the branching of the radius is closer to the base of the wing and the costa extends a little farther beyond R_s. That the relationships are with the CATOCHINI, however, is shown in the male genitalia which similarly have a terminal brush on the disticlasper, the sclerotized spermathecae of the female, and the absence of the humeral cross-vein and the plical vein. The antennae of *Tritozyga* are very similar in structure to the antennae of *Neocatocha;* and the bend in Cu_2 is rather characteristic of several catochine genera.

The genus *Tritozyga* may be briefly characterized as follows, on a basis of the few specimens of the known species.

Antennae of both sexes similar, with reduced number of segments: 2+8 in male, 2+6 in female; terminal antennal segment long, compound, resulting from fusion of two segments in male and three segments in female, with distal bristles; flagellar segments short and broad, without distal stems; each flagellar segment, including only proximal division of terminal segment, with a proximal whorl of long bristles which are set very wide apart and with a pair of distal, bud-like sensoria. Ocelli three. Lateral eye bridge without facets, the dorsal eye widely separated, 6 to 7 facets wide at middle, Palpi 4 segmented, the first three segments subequal, the fourth a little longer; first segment of female with a small pocket of sensory bristles on proximal portion inside. Wings moderately covered with long, narrow macrotrichia; R_5 only two-thirds as long as wing, the costa extending only a little beyond this and then with a break; R_s obliterated; fork of M very uneven, the upper branch sigmoid; M_{3+4} evanescent at proxmal end; Cu_2 rather strongly bent, curved and tapering beyond this, evanescent at distal end. Claws slender, acute distally; empodium wide, about as long as claws, densely clothed with short hairs below. Spermathecae two, rather small, round, heavily pigmented including a small neck of the tube. Disticlasper of male genitalia with distal brush.

Felt's figure of the wing, although substantially correct, is somewhat misleading: actually the costa is strong until slightly beyond R_5 where there is a distinct break and R_5 is slightly curved upward at junction with the costa; R_5 is slightly widened at the position of the obsolete R_s where it is approximate to R_1; r-m below this point is curved downward to M; the upper branch of the median fork is strongly curved at a blunt right angle near origin.

Tritozyga sackeni Felt

Tritozyga sakeni Felt. Jour. N. Y. Ent. Soc., 19: 32, 1911; Felt, Bull. N. Y. State Mus., 165: 149, 1913 (fig. wing).
Tritozyga fenestra Felt. Insec. Inscit. Mens., 2: 117, 1914. New synonymy.
Tritozyga borealis Felt. Jour. N. Y. Ent. Soc., 27: 279, 1919. New synonymy.
Neocatocha cranbrooki Felt. Canad. Ent., 58: 266, 1926. New synonymy.

Felt gave no reason for differentiating his proposed species, and the writer has been unable to find any significant differences in the types. Only the type of *cranbrooki* is in fairly good condition, and its wings have been malformed by potassium hydroxide. The male genitalia of the single male are lateral view and cannot be characterized.

Monotype.—Female, in the Museum of Comparative Zoology.

Types of synonyms.—*Fenestra:* monotype female, in the New York State Museum; *borealis:* lectotype female by present designation, in the New York State Museum; *cranbrooki:* monotype female, in the New York State Museum.

Specimens examined.—DISTRICT OF COLUMBIA: one male (monotype of *sackeni*). NEW YORK: one female, Albany, June 3, 1914, D. B. Young (monotype of *fenestra*); one female, one male, Keene Valley, September 15, 1917, H. Notman (lectotype and paralectotype of *borealis*). BRITISH COLUMBIA: one female, Cranbrook, October 14, 1922, C. Garrett (monotype of *cranbrooki*).

Genus **Neocatocha** Felt

Neocatocha Felt. Jour. N. Y. Ent. Soc., 20: 236, 1912; Felt, Bull. N. Y. State Mus., 165: 151, 1913; Kieffer, Gen. Insect., 152: 307, 1913; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938.
Konisomyia Felt. Insec. Inscit. Mens., 2: 118, 1914; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 1938. New synonymy.

Genotype.—*Neocatocha marilandica* Felt, monobasic and by original designation.

Genotype of synonyms.—*Konisomyia:* (*Konisomyia fusca* Felt) = *Neocatocha marilandica* Felt, monobasic and by original designation.

Edwards excluded from consideration the genus *Konisomyia*, suspecting that it belonged to the SCATOPSIDAE. This genus, erected on a basis of wing venation, is here shown to be a strict synonym of *Neocatocha*, erected on a basis of antennal structure. The wing venation is similar to that found in other catochine genera except that R_s is lacking. *Neocatocha* was originally regarded by Edwards (1929) as a synonym of *Catocha*, although he later considered it as possibly distinct. The genus is actually quite distinct, and the following characterization is drawn up from the several known females.

Female antenna with 2+6 segments; terminal segment elongate, rather tapering, compound, composed of three united segments; flagellar segments short and broad, without distal stems, each with a proximal whorl of bristles set wide apart and with a pair of distal, bud-like sensoria. Ocelli three. Lateral eye bridge devoid of facets or with one facet near the middle, the dorsal eye widely separated. Palpi four segmented, the first enlarged, with a deep sensory pore on inside face distally. Wings clothed with slender macrotrichia; C extending to a wide break just above M_1; R_s obsolete; medial fork even: M_{3+4} evanescent at proximal end; Cu_2 strongly bent, and curved beyond this. Claws slender, acute distally; empodium wide, as long as claws. Spermathecae two, rather small, round, heavily pigmented, including a small neck of the tube.

Felt's sketch of the wing of *marilandica*, as published by Edwards, is very inaccurate and misleading: actually, R_s is obsolete, its position being indicated only by a slight widening of R_5; r-m cross-vein is two or three times as long as R_s, continuous with R_5, but curving downward; CuP is distinct and free; Cu_2 is tapering beyond bend, evanescent at distal end. Felt's drawing of the empodium is too short, and that of the palp omits the characteristic sensory pore.

Neocatocha marilandica Felt

Neocatocha marilandica Felt. Jour. N. Y. Ent. Soc., 20: 236, 1912; Felt, Bull. N. Y. State Mus., 165: 151, 1913 (fig. antenna, palp, claws); Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938 (fig. wing).
Konisomyia fusca Felt. Insec. Inscit. Mens., 2: 118, 1914. New synonymy.
Konisomyia borealis Felt. Jour. N. Y. Ent. Soc., 27: 279, 1919. New synonymy.

The writer has been unable to make any distinctions in the three type females representing Felt's three species. Felt gave no reason why he considered the second species of *Konisomyia* distinct.

Monotype.—Female, in the New York State Museum.

Types of synonyms.—*Fusca:* monotype female, in the New York State Museum; *borealis:* monotype female, in the New York State Museum.

Specimens examined.—MARYLAND: one female, Plummer's Island, March 24, 1907, W. L. McAtee (monotype of *marilandica*); one female, Plummer's Island, April 12, 1914, W. L. McAtee (determined by Felt as *marilandica*). NEW YORK: one female, Albany, June 2, 1914, D. B. Young, on window (monotype of *fusca*); one female, Albany, June 6, 1914, D. B. Young on window (determined by Felt as *fusca*); one female, Keene Valley, September 15, 1917, H. Notman (monotype of *borealis*).

Genus **Catocha** Haliday

Catocha Haliday. Ent. Mag., 1: 156, 1833; Macquart, His. Nat. Insect. Dipt., 2 (suppl.): 654, 1835; Westwood, Introd. Classif. Insects, Gen. Syn. p. 127, 1840; Walker, Insect. Brit., Dipt., 3: 59, 1856; Schiner, Fauna Austr., Flieg., 2: 412, 1864; Winnertz, Verh. Zool.-Bot. Ges. Wien, 20: 27, 1870; van der Wulp, Dipt. Neerl., p. 78, 1877; Skuse, Proc. Linn. Soc. N. S. Wales, 3: 143, 1889; Kieffer, Bull. Soc. Hist. Nat. Metz, (ser. 2) 8: 52, 1898; Kieffer, Ann. Soc. Ent. France, 69: 438, 1900; Felt, Bull. N. Y. State Mus., 124: 308, 1908; Felt, Jour. N. Y. Ent. Soc., 19: 31, 1911; Enderlein, Arch. Naturg., 77 (Bd. 1, Suppl. 3): 192, 1911; Felt, Bull. N. Y. State Mus., 165: 129, 1913; Kieffer, Gen. Insect., 152: 306, 1913; Edwards, Ent. Mon. Mag., 65: 10, 1929; Mani, Rec. Ind. Mus., 36: 378, 1935; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 104, 1938.

Mimosciara Rondani. Sopra Alc. Gen. Inset, Ditt. Mem. Soc. Serv. Ditt. Ital., 1840—reviewed in Isis von Oken, 1844: 451; Rondani, Nuov. Ann. Sci. Nat. Bologna, (ser. 2) 6: 372, 1846; Bigot, Ann. Soc. Ent. France (ser. 3) 2: 475, 1854; Kieffer, Bull. Soc. Ent. France, 69: 442, 1900; Coquillett, Proc. U. S. Nat. Mus., 37: 570, 1910; Edwards, Ent. Mo. Mag., 65: 10, 1929.

Furcinerva Rondani. Nuov. Ann. Sci. Nat. Bologna, (ser. 2) 6: 369, 1846 (based on the union of *Zigoneura*, *Lestremia*, *Mimosciara*, and *Catocha*); Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 461, 1854; Kieffer, Bull. Soc. Ent. France, 69: 443, 1900; Coquillett, Proc. U. S. Nat. Mus., 37: 545, 1910.

Macrostyla Winnertz. Ent. Ztschr. Ent. Ver. Stettin, 7: 20, 1846; Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 461, 1854.

Molobraea Loew.* Dipt. Beitr., 4: 12, 20, 1850 (a manuscript name of Rondani's based on the union of *Catocha*, *Lestremia*, *Mimosciara*, and *Anarete*); Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 462, 1854 (as *Molobrea*).

Molobraea (*Molobraea*) Loew. Dipt. Beitr., 4: 22, 1850 (based on the union of *Lestremia* and *Mimosciara*).

Molobraea (*Catocha*) Loew. Dipt. Beitr., 4: 22, 1850.

Yposatoea Rondani. Dipt. Ital. Prod., 1: 198, 1856 (based on the union of *Lestremia*, *Zigoneura*, and *Mimosciara*); Coquillett, Proc. U. S. Nat. Mus., 37: 621, 1910.

Genotype.—*Catocha latipes* Haliday, monobasic.

Genotype of synonyms.—*Mimosciara: Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910; *Furcinerva: Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910; *Macrostyla: Macrostyla latipes* Winnertz, monobasic; *Molobraea: Mimosciara molobrina* Rondani, by present designation; *Yposatoea: Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910.

Rondani's figure (1946, p. 372) of the wing of *Mimosciara lestremina* Rondani shows that this species belongs to the genus *Catocha*. No

*According to Neave's "Nomenclator Zoologicus," *Molobraea* was described in Loew's "Ueber den Berstein und die Berstein fauna (Dipteren)" p. 32, published in Berlin, 1850. The writer has not seen this paper.

differences between the venation of *M. lestremina* and the genotype, *M. molobrina*, were noted by Rondani, and it would appear that they are congeneric. Edwards suggested that *Mimosciara* is probably a synonym of *Catocha* (and that *molobrina* is probably a synonym of *latipes* Haliday), not *Lestremia* as commonly listed, and it seems that this course should be followed.

Edwards has shown that *Catocha* contains a single species or species complex in northern Europe. A single, closely related species is known from the United States.

Catocha slossonae Felt

Catocha slossonae Felt. Bull. N. Y. State Mus., 124: 309, 1908; Felt, Bull. N. Y. State Mus., 165: 132, 1913 (fig. antennal segment, distal segments of palp).
Neocatocha sylvana Felt. J. N. Y. Ent. Soc., 27: 280, 1919. New synonymy.

Catocha slossonae is very similar to *C. latipes* Haliday and may prove to be a synonym of that species. The venation is as in the typical form figured by Edwards, 1938 (fig. a), except that the margin between the branches of the medial fork is only one-half as long as M_2. The male genitalia are similar to the typical form (fig. k), although the black patch of the disticlasper appears longer and narrower. The bristles of the antennal whorl are more numerous (fig. e).

The female described by Felt as *Neocatocha sylvana* is very similar to *latipes* Haliday, and there is no good reason for considering it separate from *slossonae*. The wings are brownish (not hyaline).

Monotype.—Male, in the U. S. National Museum.

Types of synonyms.—*Sylvana:* monotype female, in the New York State Museum.

Specimens examined.—NEW HAMPSHIRE: one male, Franconia, A. T. Slosson (monotype of *slossonae*). NEW YORK: one female, Keene Valley, August 14, 1917, N. Hotman (monotype of *sylvana*).

Genus **Eucatocha** Edwards

Eucatocha Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938.

Genotype.—*Catocha barberi* Felt, monobasic and by original designation.

The genus *Eucatocha* is represented by a single species the female of which is unknown.

Eucatocha barberi (Felt)

Catocha barberi Felt. Bull. N. Y. State Mus., 165: 131, 1913.
Eucatocha barberi (Felt): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938 (fig. wing, male genitalia, antennal segment).

This species has been adequately redescribed by Edwards after examining the paralectotype male. The lectotype, selected by C. T. Greene, clearly shows three ocelli; the hypopygium is lateral view.

Lectotype.—Male, by present designation, in the U. S. National Museum.

Specimens examined.—WISCONSIN: two males, Crab Lake, Vilas Co., December, 1907, H. S. Barber, —30° F. (lectotype and paralectotype of *barberi*).

Genus **Anocha** n. gen.

Genotype.—*Neocatocha spinosa* Felt.

Anocha is closely related to *Catarete* Edwards (1929) from which it differs in having R_5 nearly straight, widely separated from the costa, Cu_2 strongly bent, M_{3+4} evanescent at proximal end, and the female antenna with eight flagellar segments, being unreduced in number. The wing venation is similar to that of *Neocatocha* from which it differs in lacking alar macrotrichia and the female flagellar segments unreduced in number, each pedicillate and with only short bristles distally. *Anocha* may be briefly characterized as follows on the basis of the several known females and one damaged male.

Antenna of female with 2+8 segments; flagellar segments short pedicillate (see figure), each densely set with sensory bristles distally on enlargement; terminal segment simple, with slender bristles distally. Antenna of male with 2+14 segments; flagellar segments with long

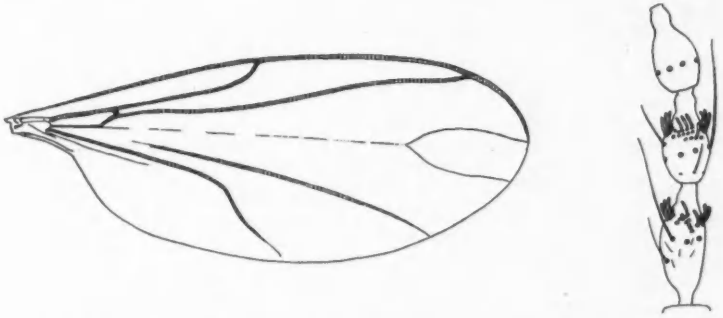

FIGURE 1. Wing and proximal flagellar segments of *Anocha spinosa* (Felt), female, Plummer, Minnesota.

distal stems and sensory bristles distally on the enlargements. Ocelli three. Lateral eye bridge three facets wide. Palpal segments four, the first with a large pocket of sensory bristles on inner side. Wings (see figure) devoid of macrotrichia; C extending to break just above M_1; R_1 long; R_5 long, slightly sigmoid, widely separated from C; R_s very short, transverse, nearly obliterated; r-m much longer than R_s, continuous with R_5 and curved downward to meet M; M_{1+2} weak, much longer than the short fork; M_{3+4} evanescent proximally; Cu_2 sharply bent and then curved, extending practically to margin, claws slightly curved, tapering; empodium very short. Spermathecae two, moderate-sized, round, heavily pigmented including narrow neck of tube.

Anocha spinosa (Felt), new combination

Neocatocha spinosa Felt. Bull. N. Y. State Mus., 165: 152, 1913.

Neocatocha nylanderi Felt. Occ. Papers. Boston Soc. Nat. Hist., 5: 207, 1926. New synonymy.

The monotype females of both of Felt's species agree well with a female collected in Minnesota. The adults appear in winter when they may be collected off snow.

Type.—Monotype female, in the U. S. National Museum.

Types of synonyms.—*Nylanderi:* monotype female, in the New York State Museum.

Specimens examined.—MAINE: one female, Woodland, December 1, 1917, Olof O. Nylander, probably off snow (monotype of *nylanderi*). MINNESOTA: one male (abdomen missing), one female, Plummer, November 17, 1933, D. G. Denning, off snow following —12° F. UNKNOWN LOCALITY: One female, December 16, 1873, A. R. Barber (monotype of *spinosa*)—this specimen could possibly be from A. W. Barber who was in Wisconsin at that time.

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BASIC BOTANY, by FRED W. EMERSON. xi+372 pages, numerous figures. The Blakiston Company, Philadelphia and Toronto, 1947. Price $4.00.

Elementary textbooks can be very useful even to professional scientists, but they rarely inspire one. Dr. Emerson's *Basic Botany* is an exception. In the first place it is a beautiful book, the binding being a colorful reproduction of a mountain scene from some arid region of the west. The reviewer suspects that the lovely blue sky and white clouds will soil readily in the hands of college students and that the result will be more conspicuous than the average dog-eared text, but the covers should have served a useful purpose by that time.

The typography and format are very clear. Although the reviewer does not like a two-column page he recognizes that this is a matter of opinion. Chapter headings are large enough to be conspicuous. They are followed by a brief general statement on the contents of the chapters and by a list of principal topics which reappear in the text as boldface paragraph heads. Line drawings are clearly executed and very well reproduced, while half-tone illustrations vary more widely in quality. A frontispiece is made up of eight colored illustrations of plants of the major groups. A novel feature of the book is the absence of figure numbers, the figures merely being placed near the part of the text which refers to them.

The contents of the book follow a familiar pattern, proceeding from biological fundamentals to metabolism, structure of plants, and special functions. Genetics and evolution are followed by a taxonomic survey of the plant kingdom and this by two ecological chapters. The book concludes with an ample index.

The author's treatment of these materials should make the book an unusually useful one. He displays a happy faculty for selecting enough facts to establish his points without making the treatment difficult or pedantic, and his facility in the use of English has produced a very readable text. Even though the reviewer's knowledge of botany is entirely adequate for his needs, he has actually enjoyed reading page after page and looks forward to having the book available for reference. Even the amazing inertia of many students who register for introductory science courses should give way before this treatment, which is little short of entertaining.

We wish the author and the publishers the success which their excellent collaboration deserves.—A. W. L.

NOTES ON THE SELYSIAN TYPES OF EPIGOMPHUS PALUDOSUS HAGEN IN SELYS

LT. COL. F. C. FRASER, I.M.S. Retd., F. R. E. S.

I am indebted to the authorities in charge of the Brussels Museum and in particular to Dr. Antoine Ball for their courtesy and kind co-operation whereby I have been able to make a re-examination of the supposed types of *Epigomphus paludosus* Hagen in Selys. The species was first described in the Syn. Gomphines, and the type, which was said to be in Dr. Hagen's collection, was given as from Brazil. Kirby, in his Cat. Odonata, 1890, p. 71, ascribed the species to Selys but the Mon. Gomphines was written in collaboration with Dr. Hagen, and the Synopsis was a résumé of this work by the two authors, as is stated in the preface to the latter work: thus the correct course to adopt in the present case is to give the authorship to Hagen *in Selys*. It is not certain whether the Hagenian types went eventually into the Selysian collection or were deposited in the Konigsberg Museum but I believe into the former prior to Hagen emigrating to the United States.

There are six specimens labelled as *Epigomphus paludsosus* in the Selysian collection and I find two pairs of the same species in the McLachlan collection now in the British Museum (Natural History) which I have also been able to examine. An examination of the Selysian specimens has resulted in the discovery that only three of them are *paludosus*, two being determined by myself as *obtusus* Selys, and the sixth specimen as *quadracies* Calvert. All except one of the specimens, a male of *paludosus*, are females and the difficulty was met with as to which of the two females of *paludosus* was the actual type. It is unfortunate that types were not designated by the old authors, so that this difficulty is constantly cropping up. In the present case, a number of facts point to one particular female as being the type. This specimen bears all the marks of old age, the wings have been glued on and the base of the abdomen has undergone much repair. It bears 3 labels: 1. Green, "Tijuca," "P. B." 2. "Collection of Selys. *Epigomphus paludosus* Hag." and 3. "*Epigomphus paludosus* H., ♀," this latter in Selys' own handwriting. "P. B." in all probability refers to P. Besehke, the collector of the type mentioned in the Mon. Gomph. It is the only specimen from Tijuca, a locality which I have not been able to find in my maps of Brazil. The male and other female and the two pairs of *paludosus* in the McLachlan collection are all labelled from Minas

EXPLANATION OF FIGURE 1

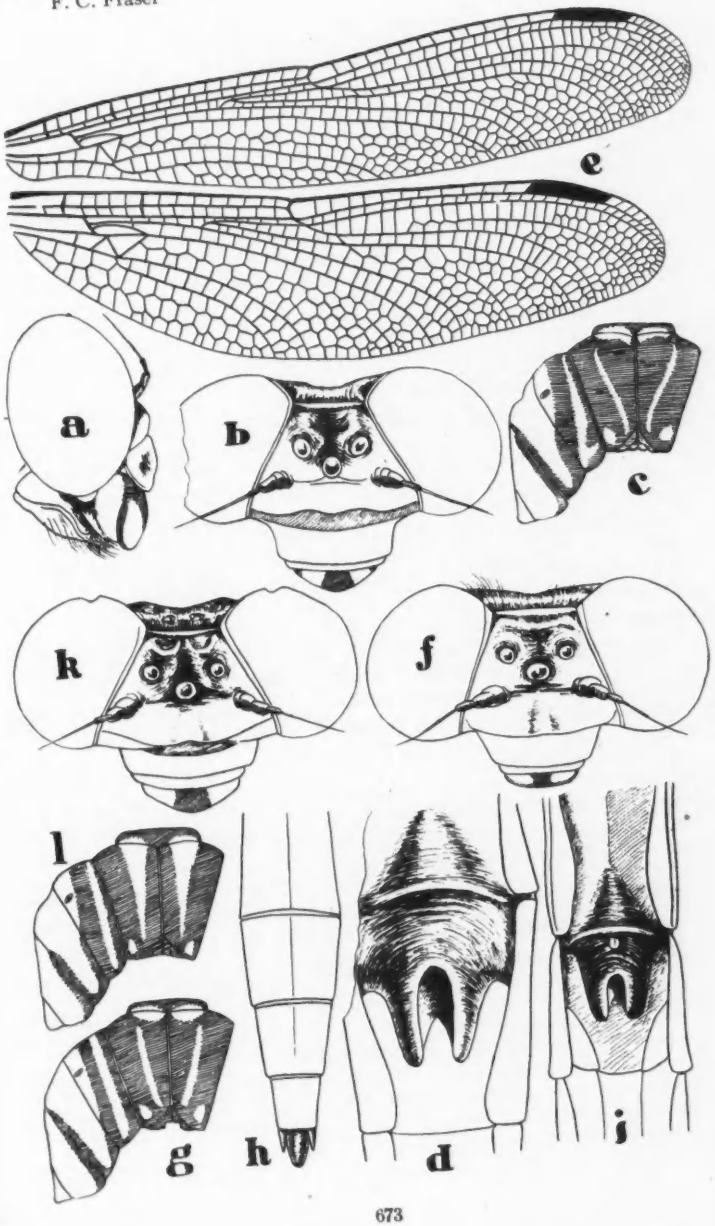
Epigomphus obtusus Selys, female. *a*. Lateral view of head. *b*. Dorsal view of head. *c*. Markings of thorax, diagrammatic. *d*. Genitalia. *e*. Wings of female.

Epigomphus paludosus Hagen in Selys. *f*. Dorsal view of head. *g*. Markings of thorax, diagrammatic. *h*. End of abdomen of female. *i*. Genitalia of female.

Epigomphus quadracies Calvert. *k*. Dorsal view of head. *l*. Markings of thorax, diagrammatic.

FIGURE 1

Types of *Epigomphus paludosus*
F. C. Fraser



Geraes, Brazil, and we know that these particular specimens were collected at a much later date as mentioned by Selys in his 3rd Add. Syn. Gomph., 1873. Thus by a process of exclusion, we are reduced to the single female from Tijuca and I think there can be no doubt about it being the actual type. I have made the following notes and figures of the six Selysian specimens in the hope that they may be of some assistance to those studying this interesting genus.

Specimen 1. Type female. Determined as *paludosus* by Selys himself. It agrees closely with the detailed description in the Mon. Gomph both as to measurements and markings although the colouring has faded and the markings of the abdomen are difficult to make out. All the legs are still intact although somewhat glued up: the hind femora bear 6–8 spines longer and more robust than the rest: nodal index of wings $\frac{12\text{–}16 \mid 17\text{–}13}{12\text{–}13 \mid 12\text{–}11}$: an incomplete basal antenodal in all wings. The antehumeral stripes (fig. 1. g.) are narrow, nearly straight, converging strongly above and well separated from the mesothoracic collar below. There is a well-defined upper triangular spot, the only vestige of a humeral stripe on each side. The vulvar scale (fig. 1, i.) is roughly half the length of segment 8, is shaped like a split-rivet, deeply incised and rather obtuse at apex. The curious cone-like structure between the anal appendages at the end of the abdomen, which Calvert terms the 11th abdominal segment, is certainly the ***appendix dorsalis***, and is highly characteristic for the genus.

Specimen 2. A male bearing 6 labels: 1. Pink, "126," 2. White with black border at one end and bearing "MLan" (? McLachlan), 3. Green, a blank. 4. White, "Minas Geraes," 5. White, "Collection Selys, *Epigomphus paludosus* Hgn" (in an unknown handwriting), and lastly 6. White, "*Epigomphus paludosus* H, ♂" (in Selys' own handwriting).

This specimen is in poor condition, the apex of the left forewing missing and the abdomen in pieces but glued on to a strip of wire, segments 3 and 6 being absent, and the 10th with the dorsum broken and the apices of the right anal appendages missing. All legs are present, the hind femora with the flexor and outer sides coated with very small spines which become arranged into outer and inner rows distally, the outer row being the more robust and most widely-set. The tibiae with a few short stout spines numbering 8 or 9 in the hind pair. Wings with nodal index: $\frac{?\text{–}14 \mid 15\text{–}11}{11\text{–}10 \mid 12\text{–}10}$; a basal incomplete antenodal in all wings; anal triangle and anal-loop both absent; 2 Cuqs in all wings save the left forewing. Markings of thorax similar to the type female but the antehumeral stripes are slightly less divergent and entirely straight. I have labelled this specimen as the ***allotype*** of *paludosus* and the intact appendages of the left side have served to furnish the figures *a* and *b*, fig. 2.

Specimen 3. A female with 2 labels: 1. Green, "Minas Geraes," and 2. White, "Collection Selys, *Epigomphus paludosus* Hg." –in an

unknown handwriting). This specimen evidently belongs to the same series in the McLachlan collection, which also came from Minas Geraes, and is entirely similar to the females in that series. It is rather smaller than the type female, Abd. 37 mm., Hw. 33 mm. Nodal index: $\frac{10\text{–}16 \mid 15\text{–}10}{10\text{–}12 \mid 13\text{–}8}$; hind femora with inner and outer rows of spines, 7–8 robust ones on the inner side and 5–6 larger ones which merge into smaller spines near base of femora. The end of the abdomen is damaged and the genitalia is missing, otherwise I can find no differences between the specimen and the type save that of size. I think this to be therefore a female of *paludosus*.

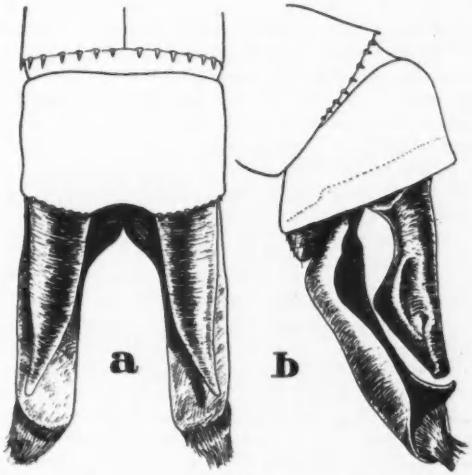


FIG. 2. *Epigomphus paludosus* Hagen in Selys. *a*. Dorsal view of segment 10 and anal appendages of male. *b*. The same seen from the left side.

Specimen 4. A female bearing 2 labels: 1. Green, "Chiriquii," 2. "Collection Selys, *Epigomphus paludosus* Hgn." (not in Selys' handwriting). The antehumeral stripes are broadly confluent with the mesothoracic collar, parallel with the middorsal carina and taper to a point ending just below the alar sinus: humeral stripes represented by upper small triangular spots as in *paludosus*. Face and frons a dull olivaceous, labrum with middle third blackish brown, outer thirds citron yellow, anterior border finely black. The posterior surface of the eyes and the upper surface of occiput are deeply pitted with scars due to pressure of the male anal appendages (fig. 1, *k*.). Nodal index: $\frac{14\text{–}19 \mid 20\text{–}13}{11\text{–}13 \mid 15\text{–}12}$; 3 Cuqs in forewings, 2 in the hind; a basal incomplete antenodal in all wings. Abdomen with

only the 3 basal segments present; genitalia missing. Femora yellow within, blackish brown outwardly. The specimen agrees most closely with Calvert's *quadracies*, for which I have determined it.

Specimens 5 and 6. Two females with identical labels. 1. Green, "S. Paulo." 2. White, "*Epigomphus paludosus* Hgn." (not in Selys' handwriting.) Abd. 45 mm., Hw. 36 mm. Nodal index: $\frac{13\text{–}18 \mid 20\text{–}13}{12\text{–}14 \mid 13\text{–}12}$, $\frac{12\text{–}18 \mid 17\text{–}12}{11\text{–}14 \mid 12\text{–}12}$; 3 Cuqs in forewings, 2 in the hind; pterostigma covering 7 cells, longer than in *paludosus*. Antehumeral stripes sinuous, more so in one specimen than in the other, widely divergent below and well separated from the mesothoracic collar. Vulvar scale rather more than half the length of segment 8. These two specimens approach *obtusus* most closely (fig. 1, *a* to *e*.).

Two pairs in the McLachlan collection are all labelled ***Epigomphus paludosus*** Hgn, and all are from Minas Geraes. They do not differ in any noticeable respects from the male and female from the same locality in the Selysian collection mentioned above. The males are in poor condition but it is possible to see that the anal appendages are identical to the male in the Selysian collection. There are thus 3 males and 4 females of *paludosus* known, type and allotype in the Selysian collection, Brussels Museum, cotypes in the McLachlan collection, British Museum.

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THE DATES AND EDITIONS OF CURTIS' BRITISH ENTOMOLOGY, by RICHARD E. BLACKWELDER. 27 pages, 4 plates, 1947. Smithsonian Miscellaneous Collections, Vol. 107, No. 5.

The early date and the extent of Curtis' work, together with his citations of genotypes, make the *British Entomology* one of the historically important entomological contributions. Its publication, however, was rather more irregular than that of most early works, hence the careful consideration of dates and type citations presented in this article is essential to its proper evaluation. The author discusses very carefully the inconsistencies of the original publication and reprints of various parts. While he is not able to clear up all uncertain points, his access to various examples of the work has enabled him to furnish a full analysis of the problems involved. In addition to his text he includes facsimile reproductions of several pages and four plates and a bibliography of forty-one items.—A. W. L.

EMBRYOLOGY OF LUCILIA SERICATA MEIGEN
(Diptera: Calliphoridae)

Part II. The Blastoderm, Yolk Cells and Germ Cells

WILLIAM A. FISH,
The Ohio State University,
Columbus, Ohio

The writer (1947) has described the embryology of *Lucilia sericata* from the time of fertilization to the fusion of the cleavage cells with the periplasm, and the consequent formation of the yolk cells. It is the purpose of this paper to present the stages in the development of the blastoderm (primary epithelium) and to describe the formation and fate of certain associated structures: the yolk cells, the germ cells, and the inner periplasm.

THE BLASTODERM

As already shown (Fish, 1947) the cleavage cells first fuse with the periplasm in the anterior pole at about the level of the original egg nucleus. This protoplasmic merger proceeds dorsally, ventrally and laterally at the same time. From this initial area the cleavage cells fuse with the periplasm anteriorly and posteriorly, reaching the posterior pole last. The nuclei of the cleavage cells are in a peripheral position in the cells at the time of fusion. Although all of the cleavage cells migrate towards the surface, not all of them attain the periplasm but some of them return into the yolk and are recognized as the yolk cells.

The egg now has the appearance (Pl. II, fig. 17) of an outer nucleated continuous layer of protoplasm enclosing the yolk in which are located large amoeboid nucleated masses of cytoplasm (yolk cells), all joined to one another and to the outside layer by fine protoplasmic strands. The whole egg can thus be considered a syncytium. In section, on the peripheral edge, the outer nucleated layer, the blastema, appears as a slightly wavy line while the medial border is indented with yolk and is very irregular. (Pl. I, fig. 1.) The nuclei are circular and lie midway between the peripheral and medial border of the blastema.

Since the area of cleavage cell fusion initially occurs at the anterior pole, it might be expected that this pole would now show a more advanced state of development than the posterior pole. However, if there is a difference in comparative rates of development this difference was not detected. The first mitoses of the blastemal nuclei apparently occur simultaneously throughout the entire layer. Shallow clefts appear on the outer blastemal border and accomplish an incomplete separation of this zone into cell territories or compartments. (Pl. I, figs. 2, 3.) These clefts soon widen and deepen until they penetrate approximately a third of the thickness of the blastemal layer. (Pl. I, fig. 3.) Each cell territory, now rendered more obvious, consists of an outer section of protoplasm and a portion (about one-half) of the nucleus. The remaining portion of the nucleus and scattered yolk

elements are contained in the undivided portion of the blastema. At this stage of development the nuclei lie near the peripheral border. Grossly, the cell territories look alike but when examined in detail there is little uniformity of size and shape.

When the next nuclear division occurs these clefts are all but eliminated and the outer blastemal border again assumes a wavy appearance. (Pl. I, fig. 4.) Generally the lengths of the waves vary but their frequency of occurrence corresponds to the number of nuclei present. The latter are now oval and appear as darkly stained masses. New clefts appear and cell territories are again formed in a fashion similar to the first formed compartments. (Pl. I, fig. 5.) These new territories resemble the first ones except that they are smaller and because of their sharply angled outer edges they are more pronounced. The width of a cell territory at its base does not greatly exceed the diameter of its nucleus. Towards the peripheral edge each compartment tapers slightly and appears somewhat like a truncated cone joined at its base to the undivided area of the blastema. If an imaginary line were drawn connecting the bases of a series of cell territories, it would be almost a straight line. The rate of penetration of the clefts into the

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EXPLANATION OF PLATE I

All figures are drawn with the aid of the Camera Lucida under the same magnification, 950×. The details are filled in under 1450×.

FIG. 1. Age, about 105 minutes. A longitudinal section through a small portion of the blastemal layer showing the disposition of two nuclei. N—nucleus; Y—yolk.

FIG. 2. Age, about 120 minutes. A similar section of a more advanced stage showing three nuclei. Observe the clefts on the peripheral margin. These clefts may occur obliquely or at right angles. C—cleft.

FIG. 3. Age, about 135 minutes. A more advanced stage showing definite marginal cell territories or compartments. The nuclei appear vacuolate. CT—cell territory.

FIG. 4. Age, about 135 minutes. A stage immediately after nuclear division showing the absence of the original clefts. The nuclei appear smaller and are more compact.

FIG. 5. Age, about 150 minutes. New clefts appear and marginal compartments are again formed. C—cleft.

FIG. 6. Age, about 165 minutes. The clefts penetrate deeply into the blastema. The protoplasm peripheral to the nuclei begins to darken. APD—area of protoplasmic darkening.

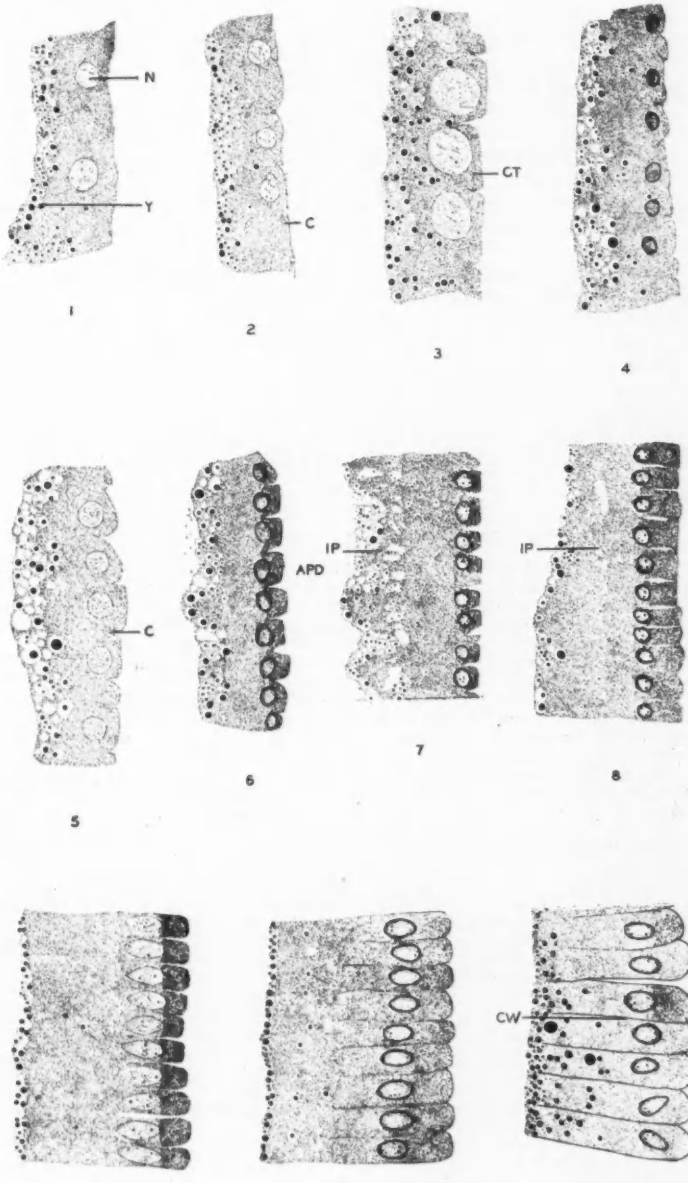
FIG. 7. Age, about 165 minutes. The darkening of the protoplasm continues. Notice particularly the addition of anucleated protoplasmic masses to the blastema. These masses fuse to form the inner periplasm. IP—inner periplasm.

FIG. 8. Age, about 180 minutes. The cell territories are now more pronounced. The nuclei are located more deeply in the blastema. The medial border of the inner periplasm begins to smooth out. IP—inner periplasm.

FIG. 9. Age, about 195 minutes. The peripheral protoplasm is now extremely darkened and appears in section as a dark band. The nuclei are spindle shaped and the fusion of the original blastema and the inner periplasm is complete.

FIG. 10. Age, about 210 minutes. The cell walls penetrate to the yolk. Notice the absorption of yolk by the blastodermal cells. As yet there are no cell walls on the bases of the cells.

FIG. 11. Age, about 210 minutes. The cell walls penetrate t? the yolk. Notice the absorption of yolk by the blastodermal cells. As yet there are no walls on the bases of the cells. CW—cell wall.



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blastema occurs relatively uniformly, perhaps more rapidly on the dorsal surface. The nuclei are now located more deeply in the blastemal layer and are arranged in an even row.

About the time of the third nuclear division a zone of enucleated protoplasm appears, the inner periplasm. (Pl. I, fig. 7.) It lies beneath the blastemal layer and as development proceeds it fuses gradually with the blastema. After this fusion is completed the "new" blastemal layer is about twice its original thickness. A more thorough description of the inner periplasm will be given in the discussion concerning yolk cells.

Simultaneously with the above development, the protoplasm of the cell territories peripheral to and surrounding the outer half of the nuclei becomes very darkly stained. (Pl. I, figs. 7, 8.) In a later stage the protoplasm is stained so intensely that the outline of the peripheral half of the nuclear membrane is difficult to detect. (Pl. I, fig. 9.)

It may be worthwhile to mention at this time an observation which may be directly correlated with some of the phenomena already described. At the time of fusion of the inner periplasm with the

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EXPLANATION OF PLATE II

Figures 12–16 are drawn with the aid of the Camera Lucida under 950× and detailed under 1450×. Figures 17–22 are composite drawings of longitudinal sections through the middle of the egg.

FIG. 12. Age, about 120 minutes. A tangential section of the blastemal layer representing a cross-section of Pl. I, fig. 2. N—nucleus.

FIG. 13. Age, about 135 minutes. Represents a cross-section of Pl. I, fig. 4, at the level of the nuclei.

FIG. 14. Age, about 165 minutes. Represents an oblique section of Pl. I, fig. 6, showing compartment arrangement peripheral to the nuclei.

FIG. 15. Age, about 180 minutes. Cross-section of Pl. I, fig. 8, showing peripheral compartment arrangement. N—nucleus.

FIG. 16. Age, about 195 minutes. Cross-section of Pl. I, fig. 11, showing definite cell walls and the honeycomb arrangement of the cells.

FIG. 17. Age, about 120 minutes. A longitudinal section of the entire egg showing the blastema, yolk cells and germ cells in their early development. A—anterior; BL—blastema; D—dorsal; GC—germ cell; N—nucleus; P—posterior; R—reticulum; V—ventral; YC—yolk cell.

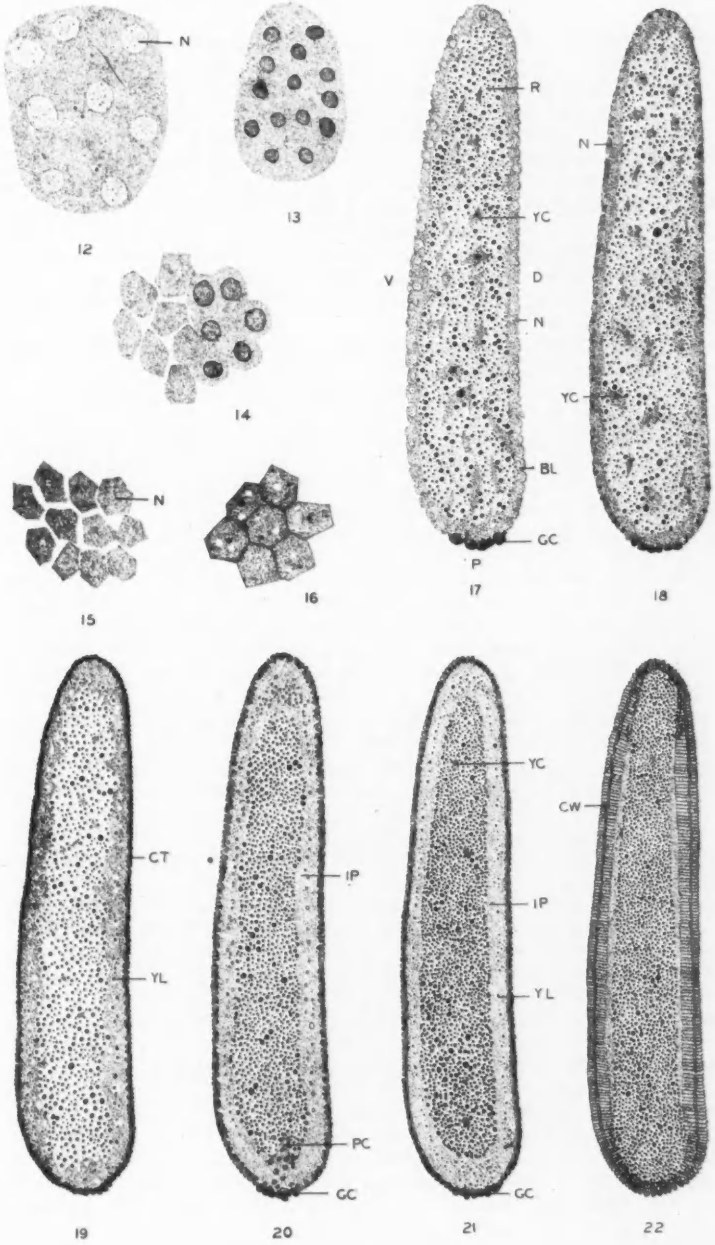
FIG. 18. Age, about 135 minutes. Notice the increase in the number of blastemal nuclei, the position of the yolk cells and the cell territory formation. N—nucleus; YC—yolk cell.

FIG. 19. Age, about 165 minutes. The yolk cells have all but disappeared from the yolk mass. The blastema is now approximately doubled in thickness. Compare this stage to that represented in Pl. I, fig. 7. CT—cell territory; YL—yolk layer.

FIG. 20. Age, about 180 minutes. The yolk mass becomes more dense and the inner periplasm smooths out on its medial surface. Observe, in the posterior pole, the inverted protoplasmic cone with its nuclei. GC—germ cell; IP—inner periplasm; PC—protoplasmic cone.

FIG. 21. Age, about 180 minutes. The blastema is thicker on the dorsal surface. Notice the distribution of the inner periplasmic layer. GC—germ cell; IP—inner periplasm; YC—yolk cell; YL—yolk layer.

FIG. 22. Age, about 215 minutes. The blastoderm is almost completed except for the narrow undivided protoplasmic strip beneath the cells of the dorsal and ventral surfaces. Absorption of yolk by the cells occurs in the polar regions. CW—cell wall.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blastemal layer and at the time of peripheral protoplasmic darkening, the greatest amount of protoplasmic surface is present. Although the amount of protoplasmic surface may not be the chief limiting factor (the chorion and vitelline membrane surround the protoplasmic elements), this increase in surface area, at least five to ten times greater than the undivided blastema, may well be a causative factor in the differential staining properties of the protoplasm, in increasing rates of certain metabolic processes, and in initiating yolk cell migration.

The row of nuclei remains constant in position and the clefts indent past it. Certain of my sections indicate that temporary fusion of the outer borders of the compartments occurs. (Pl. I, fig. 8.) At this time the width of the base of the cell territory is narrower than the width of its outer margins.

Meanwhile the inner border of the blastema has smoothed out and yolk material accumulates at this surface. The outer borders of the cell territories assume a less angular appearance and gradually become rounded. (Pl. I, fig. 10.) Cell walls appear first on the peripheral margin and slowly penetrate the undivided blastema. When they have almost reached the inner border yolk material flows into the cells. (Pl. I, fig. 11.) There is no observable difference in the physical nature of the yolk material after it passes into the cells. It is difficult to determine whether the movement of yolk into the cells occurs first at the anterior or posterior pole. My sections indicate that it occurs first in the posterior pole in the region of the germ cells. As yet there is no cell wall on that portion of the cell in contact with the yolk mass.

So far the development of the blastoderm has been discussed only from a two dimensional viewpoint. In cross section of the cell territories (a tangential section of the egg), the edges of the territories in the earlier stages are somewhat asymmetrical and are widely separated from one another at their outer borders. Some surfaces of the cell are broadly rounded while others of the same cell may be angular. (Pl. II, fig. 14.) As development proceeds a cross section of cell territories, after the cell walls have formed, is similar in appearance to the comb of the honey-bee. (Pl. II, fig. 16.)

The time required for blastodermal development beginning with the nuclear penetration of the periplasm is about one hour and forty-five minutes.

Except for the lack of cell walls on their base, the blastodermal cells are now complete. In comparing this stage with an early blastemal stage the following contrasts are apparent. Instead of a continuous narrow outer layer, the blastoderm has a divided thick outer layer; instead of a yolk mass with yolk particles widely scattered, a yolk mass with elements relatively dense; instead of numerous large amoeboid cells in the yolk mass joined together by a profuse reticulum, a yolk mass with a few degenerate cells joined by a reduced reticulum.

If a series of successive stages in the development of the blastoderm are observed, viewing only a portion of the blastemal layer, a misleading interpretation may result, namely, that the cell territories push outward while the associated structures remain in a relatively fixed position. If this were the case the diameter of the egg would be greatly increased by the time of cell wall formation. Actually, however,

measurements indicate that the egg, exclusive of its membranes, is slightly smaller at the blastodermal stage than at the early blastemal stage.

THE YOLK CELLS AND INNER PERIPLASM

As already mentioned, not all of the cleavage cells merge with the periplasm, but some of them, after migrating almost to the periphery, return back into the yolk mass. These cells are here considered yolk cells. Each consists of an irregular mass of cytoplasm frequently indented by yolk particles and usually containing a single nucleus. In *Lucilia sericata* they are numerous and are scattered regularly throughout the yolk mass.

Nelson (1915) classifies yolk cells as primary and secondary. This classification is based only on their time of origin. The primary yolk cells are those which remain behind in the yolk; the secondary cells are those which enter the yolk from the blastoderm during its formation.

Shortly after the cleavage nuclei have penetrated the periplasm numerous yolk cells may be seen lying within the yolk mass. However, this observation is not sufficient to warrant the statement that they are true primary yolk cells, i.e., they are cells that have lagged behind in the yolk. An incomplete series of stages at this period of development may lead to this conclusion. Actually, however, at the exact time of fusion of the cleavage cells with the periplasm no yolk cells can be seen in the yolk mass. All of the cleavage cells migrate towards the periphery where the majority fuse with the periplasm. The remaining cells turn back into the yolk. Thus in the strict sense of Nelson's definition they cannot be regarded as true primary yolk cells. (The writer (1947) called these cells the primary yolk cells.)

To understand more fully the fate of these cells in this species the origin of the inner periplasmic layer must be taken into consideration. Although the evidence presented here is not conclusive it indicates the following conditions: an actual remigration of some yolk cells towards the periphery which help form the inner periplasm, and a partial degeneration of some of them in the yolk. (Pls. II, III, figs. 19, 24.)

It has been pointed out that the width of the blastemal layer is approximately doubled during the blastodermal development. Since there is no extrinsic source of nutritive materials this increase of material must originate by the transfer of substances from within the egg itself.

Simultaneous with the doubling in thickness of the blastema the yolk mass contains only a few cells within it and these appear very different in structure from the yolk cells of the early blastema. The cytoplasm of these cells appears very concentrated and the size of the cells is greatly diminished. In addition to these observations the medial blastemal surface is now extremely irregular and very closely resembles the medial surface of the periplasm at the stage of original fusion of the cleavage cells with the periplasm (Fish, 1947, Pl. VI, fig. 18). Between the medial border of the original blastema and the peripheral border of the now-forming inner periplasmic layer can be found numerous "engulfed" yolk particles. (Pls. II, III, figs. 19, 24.) A similar process of "engulfing" yolk elements was readily observed when the cleavage cells first merge with the periplasm. This occurs,

apparently, when elements of yolk, which have been "pushed" peripherally by the amoeboid cleavage cells, become surrounded when the cells complete their fusion with the periplasm.

Within a period of several minutes the medial irregular boundary of the newly formed layer gradually smoothes out. The egg, in most regions, may now be divided into four distinct zones. Proceeding from the outside there is (1) an outer layer, the blastema, consisting of two definite areas, the divided or cellular portion and the undivided or continuous portion, (2) a layer of yolk material, narrowest on the dorsal surface and widest at the anterior pole, (3) a second protoplasmic layer, the inner periplasm and (4) the main yolk area. (Pls. II, III, (figs. 21, 25.)

In regard to the distribution of the inner periplasm among the muscids, there are various interpretations by different authors. According to Weisman (1863), the inner periplasm is a uniformly thick layer under the entire blastoderm. Graber (1889) has stated that this layer exhibits no uniform arrangement. Noack (1901) however, states that these two views are incorrect. Briefly he describes the inner periplasm as being present only in the anterior pole and in the dorsal and ventral regions; its distribution is not uniform but is thickest in the dorsal region.

Assuming that the development of the inner periplasm does not vary markedly in different species of Calliphoridae, then my observations on *Lucilia sericata* are essentially in agreement with Noack's on *Calliphora erythrocephala*. There are, however, several points of difference. My sections show that the inner periplasm may also be developed in the posterior pole. (Pl. II, fig. 21.) This region of the inner periplasm is not as clearly outlined as that of the anterior pole chiefly because of the comparatively great amount of yolk elements scattered within the protoplasm in this area. In addition, not all individuals even from the same parents, develop the inner periplasm in precisely the same manner. In exceptional cases, even after the inner periplasm was completely developed, no difference in its thickness on the ventral or dorsal surface was detected.

As concerns the fate of the inner periplasm, it fuses with the original blastemal layer, becomes divided by the cell walls and thus enters into the cytoplasmic makeup of the individual cells.

EXPLANATION OF PLATE III

Figures 23–26 are drawn under 264× and detailed under 950×.

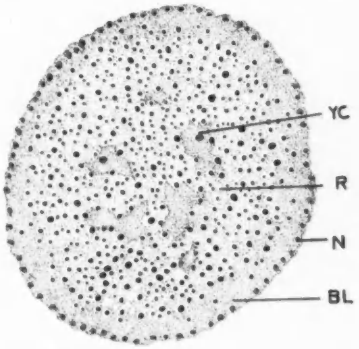
FIG. 23. Age, about 120 minutes. Cross-section taken at level X, Pl. II, fig. 18. BL—blastema; N—nucleus; R—reticulum; YC—yolk cell.

FIG. 24. Age, about 165 minutes. Cross-section at level X, Pl. II, fig. 19. Notice the disappearance of the large yolk cells and the doubling in thickness of the blastema. YC—yolk cell.

FIG. 25. Age, about 180 minutes. Cross-section at level X, Pl. II, fig. 21. BL—blastema; IP—inner periplasm; Y—yolk; YL—yolk layer.

FIG. 26. Age, about 180 minutes. Cross-section at level X, Pl. II, fig. 20, about thirty microns from posterior pole, showing germ cells and inverted protoplasmic cone. GC—germ cell; PC—protoplasmic cone.

FIG. 27. Age, about 180 minutes. A longitudinal section of the protoplasmic cone showing the germ cells and cone nuclei. Drawn under 950× and detailed under 1450×. DN—degenerating nucleus; GC—germ cell.



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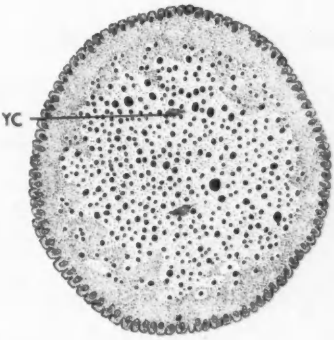

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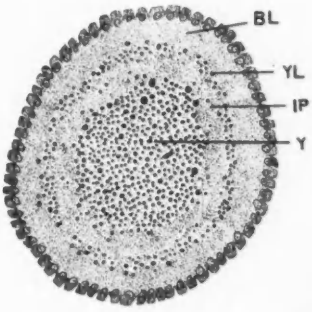

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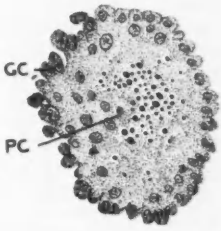

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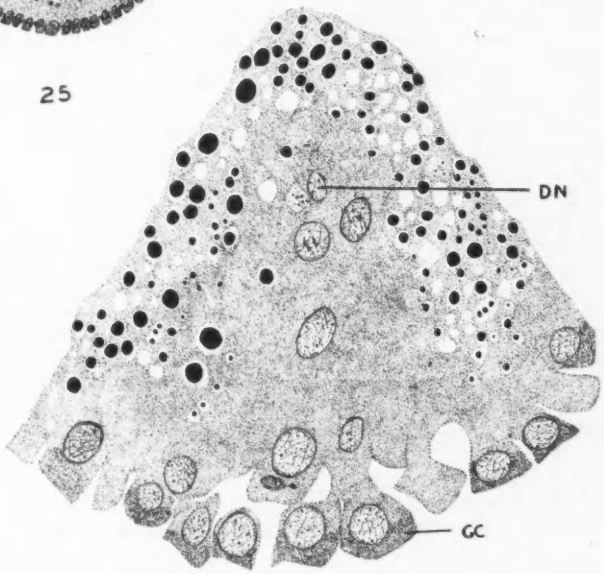

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While these changes are occurring the protoplasmic reticulum of the yolk mass, already diminished by the migration of the cleavage cells, undergoes still greater diminution. Whether it is transferred directly to the blastema by yolk cell migration, whether it is absorbed in the yolk mass and later reformed in the inner periplasm or whether absorption occurs without reformation was not observed. In view of the fact that a part of the reticular protoplasm was transferred to the periplasm with the cleavage cells in their migration, it would then appear that a similar transfer of reticulum might occur when the yolk cells migrate towards the blastema.

THE GERM CELLS

To avoid repetition, since the subject of germ cells in muscids has already been described with uniformity by various authors, and notably Noack (1901) and Auten (1934), the discussion following will be brief and of a general nature. My observations are in close agreement with those reported by the above mentioned authors.

On the dorsal surface of the egg, in the periplasm of the posterior pole, is a darkly-staining diffuse inclusion, the oösome or germ cell determinant. Noack describes this inclusion as rod-like. However, in agreement with Auten, the germ cell determinant in this species consists of a relatively wide band of granular material.

As the cleavage cells penetrate the dorsal surface of the posterior pole they break up and absorb this inclusion and appear as darkly stained cells protruding slightly from the polar surface. Exactly how many cells initially break up this inclusion I cannot say with certainty except that it is more than one (probably seven to ten).

The ensuing development is relatively easy to follow up to the time where the blastodermal cells become peripherally darkened. Although the blastodermal cells are for the most part columnar, those in the curvature of the poles appear rounded. For this reason it is almost impossible to accurately detect the limits of the germ cells from those of the blastodermal cells. In general the rate of increase in numbers of these two types of cells is about the same.

Perhaps the most interesting phenomenon associated here is the development of an inverted protoplasmic cone in the posterior dorso-polar area. (Pls. II, III, figs. 20, 26, 27.) This development occurs at the same time as the formation of the inner periplasm. Some of the germ cell nuclei (and perhaps blastodermal cell nuclei) migrate from their peripheral position into this cone. In one cone I have counted nine of these nuclei, two of which showed signs of degeneration. (Pl. III, fig. 27.)

As concerns the fate of this cone and its nuclei, I am uncertain. From all appearances it rapidly degenerates for it is not evident during the later stages of the development of the blastoderm. Noack states that this cone gives rise to yolk cells.

SUMMARY

1. There is no observable difference in the developmental rates of the anterior and posterior poles during the formation of the blastoderm.

2. The blastema is divided into cell territories by clefts which appear peripherally, and gradually penetrate the blastema.

3. The blastema approximately doubles in thickness by the addition of the inner periplasm. The latter probably has a twofold origin: (a) by the fusion of yolk cells which have migrated towards the periphery, (b) the transfer of protoplasmic reticulum from the yolk area.

4. The inner periplasm is present dorsally, ventrally and in both poles of the egg.

5. *Lucilia sericata* possesses no true primary yolk cells; that is, none of the cleavage cells remain "in situ" in the yolk.

6. Yolk material flows into the blastodermal cells when the cell walls are almost in contact with the yolk.

7. The enormous increase in the protoplasmic surface may be a causative factor in yolk cell migration and other associated phenomena.

8. The germ cell determinant inclusion is not rod-like but a relatively large diffuse mass of granules.

9. The rate of germ cell formation closely parallels the rate of blastodermal cell development.

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CHECKLIST OF THE COLEOPTEROUS INSECTS OF MEXICO, CENTRAL AMERICA, THE WEST INDIES, AND SOUTH AMERICA, Part 5, by RICHARD E. BLACKWELDER. iv+765–925 pages, 1947. United States National Museum, Bulletin 185.

With the appearance of part 5 it was expected that the completion of this extensive list could be announced, but it proves to be the completion of the checklist only. An additional part is promised to include the bibliography and an index to the genera and higher categories.

Continuing the format of the preceding parts, this one includes the families Anthribidae, Brentidae, Scolytidae, Coptonotidae, Platypodidae, Curculionidae and Cerasommatidiidae, and as an addendum to page 270, the family Chelonariidae.

Since the Checklist includes the geographic distribution of the species and a cryptic reference to each original description, the appearance of the final part should extend its value to coleopterists far beyond the usual limits of such lists.

—A. W. L.

DIFFERENCES IN THE OCCURRENCE OF NYMPHS OF TWO SPECIES OF BURROWING MAYFLIES IN FISH STOMACHS[1]

JUSTIN W. LEONARD,
Michigan Department of Conservation,
Ann Arbor, Michigan

In many of the lakes of southern Michigan two species of burrowing mayflies, *Ephemera simulans* (Say) and *Hexagenia occulta* (Walker)[2] are quite abundant. Bottom samples taken in these lakes by survey parties from the Michigan Institute for Fisheries Research have frequently revealed dense concentrations of nymphs and have shown that the two species often occur together, sometimes appearing in approximately equal numbers in a given Ekman or Peterson dredge haul.

The habits of nymphs of the two species have been little studied in nature. In particular, the depth to which they generally burrow, and the possibly different levels of the substrate which they may occupy at different times of day and night, have not been established. Ide (1935) found that burrowing nymphs of *Ephoron leukon* inhabiting stony riffles of an Ontario stream had the habit of " . . . avoiding light during the day in the deeper part of the tube and coming up to the open end in the evening to feed." In a sand-bottom trout stream in Montmorency County, Michigan, where *Hexagenia recurvata* is abundant, the writer has seldom found the nymphs less than four inches below the surface of the stream bed.

The rate of occurrence of burrowing mayfly nymphs in fish stomachs may offer certain clues to their habits. It is commonly thought by fishery biologists that the diet of fishes in lakes and streams is determined largely by what potential food organisms are available to the fish. Forbes (1888) found that nymphs of Hexagenia (species undetermined) composed about one-tenth of the total food of many fishes from Illinois waters examined by him. Neither he nor various workers who have reported Hexagenia nymphs from fish stomachs in more recent years have supplied adequate information as to the season when their specimens were taken, although Neave (1932), after stating that nymphs of *H. occulta* were a very important food for sturgeon, whitefish, tullibee, goldeye and sauger in Lake Winnipeg, inferred that they were important the year around when he wrote " . . . owing to the limited season during which they [the winged phases] are available and because most of the marketable fish are bottom feeders, their direct importance as a food supply is negligible as compared with the nymphal stages." Little has been reported of the occurrence of Ephemera nymphs in fish stomachs although Ricker (1934), referring to a form listed by him as "*Ephemera* cf. *simulans*," stated that it was "found [in brook trout

[1]Contribution from the Michigan Institute for Fisheries Research.
[2]The form listed by Spieth (1941) as *Hexagenia limbata occulta* (Walker); the name used here follows Needham, Traver and Hsu (1935).

stomachs] throughout the year; excessively abundant at time of emergence."

In Birch Lake, an oligotrophic lake in southwestern Michigan, both *E. simulans* and *H. occulta* are plentiful. In connection with a fisheries management experiment, a series of 322 stomachs of rainbow trout (*Salmo gairdnerii irideus* Gibbons) 7⅝ to 22½ inches in length was collected from Birch Lake over a six-year period embracing a seasonal span of 31 weeks, from May 21 to December 19. Except for a few

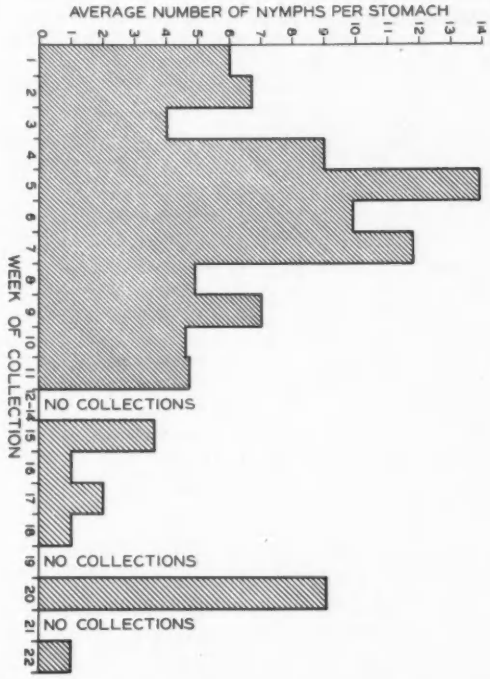

FIGURE 1. Histogram showing average number of *Hexagenia occulta* nymphs per stomach in rainbow trout stomachs containing the species, collected over a 22-week period, June 25 to November 20.

specimens taken in gill nets, all the fish were caught by anglers and the stomachs collected by a biologist acting as creel census clerk. Analysis of the contents of these stomachs revealed a striking disparity in the frequency of occurrence of the two species of ephemerines. *Ephemera simulans* appeared on only six dates: May 23, June 25 and 27, July 30, and August 2 and 3. Stomachs of trout taken on May 23, when a mass emergence of *simulans* took place, averaged 507 nymphs and 106

subimagoes per stomach, one 18-inch rainbow containing 789 nymphs and 232 subimagoes. In collections made on the other dates, *simulans* nymphs occurred in single stomachs at an average rate of three per stomach. By contrast, *Hexagenia occulta* nymphs were of steady occurrence in stomachs throughout the entire period covered by col-

TABLE I

AQUATIC INSECTS APPEARING IN THE DIET OF RAINBOW TROUT COLLECTED FROM BIRCH LAKE, CASS COUNTY, MICHIGAN, OVER A SIX-YEAR PERIOD AND A SEASONAL SPAN OF 31 WEEKS FROM MAY 21 TO DECEMBER 19.

An asterisk (*) denotes values less than one-half of one percent.

SPECIES[1]	Average number of organisms in stomachs containing them	Percent of stomachs containing organism	Percent of total volume of aquatic insects	SPECIES	Average number of organisms in stomachs containing them	Percent of stomachs containing organism	Percent of total volume of aquatic insects
EPHEMEROPTERA	.....	66	77	COLEOPTERA (cont'd)			
Ephemera simulans	274.0	3	(29)	Gyrinidae	1.0	1	.....
Hexagenia occulta	7.0	64	(48)	Hydrophilidae	1.0	1	.....
Ephemerella temporalis	4.7	1	.....	Dryopidae	1.0	1	.....
Baetinae	1.0	2	.....	*Donacia* sp.	2.0	1	.....
Callibaetis sp.	1.0	*	.....	TRICHOPTERA	.....	23	14
ODONATA	.....	9	1	Hydroptilidae	1.9	5	.....
Coenagrioninae	1.0	4	.....	*Oxyethira* sp.	1.2	2	.....
Enallagma spp.	1.7	3	.....	*Banksiola selina*	21.0	1	.....
Amphiagrion saucium	1.0	1	.....	*Phryganea* cf. *cinerea*	11.2	6	.....
Neogomphoides obscura	1.0	*	.....	Limnephilidae	1.0	1	.....
Stylurus sp.	2.0	*	.....	*Leptocella exquisita*	1.5	1	.....
Epicordulia princeps	1.0	*	.....	*Leptocella albida*	4.0	6	.....
Tetragoneuria simulans	1.0	1	.....	*Oecetis* sp.	1.0	1	.....
Libellula sp.	1.1	2	.....	*Oecetis eddlestoni*	1.0	*	.....
Plathemis lydia	1.0	*	.....	*Triaenodes tarda*	1.0	*	.....
NEUROPTERA	.....	8	1	*Triaenodes injusta*	2.0	*	.....
Sialis infumata	2.5	8	.....	*Mystacides* sp.	2.0	1	.....
PLECOPTERA	.....	*	*	*Mystacides sepulchralis*	1.0	1	.....
Isoperla sp.	1.0	*	.....	*Brachycentrus* sp.	1.0	1	.....
HEMIPTERA	.....	2	*	DIPTERA	.....	77	6
Arctocorisa sp.	1.5	2	.....	*Tipula abdominalis*	1.0	1	.....
Notonecta undulata	1.0	*	.....	Chironomidae[2]	12.5	76	.....
Belostoma flumineum	1.0	*	.....	Ceratopogonidae	5.2	7	.....
COLEOPTERA	.....	6	1	*Culex* sp.	1.0	1	.....
Haliplus sp.	1.0	*	.....	*Chaoborus punctipennis*	1.0	*	.....
Dytiscidae	1.0	1	.....	*Simulium venustum*	1.0	*	.....

[1]All species in immature stages except: *Ephemera simulans*, both nymphs and subimagoes; all Hemiptera, adult; *Haliplus* sp. and *Donacia* sp., adult; *Tipula abdominalis* and *Culex* sp., larvae and adults.

[2]Included *Polypedilum nubeculosum*, *Tanypus stellatus*, *Tanytarsus dimorphus*, *Chironomus plumosus*, *obiferus* and *modestus*.

lections. They first appeared in trout caught on June 25; their occurrence during the ensuing 26-week span, summarized by weekly intervals, is shown in figure 1. It will be seen that subimaginal and adult specimens were not eaten, although some of the nymphs taken in June appeared to be mature, the females with well developed eggs. Failure of the trout to feed on either of the winged stages is probably explained

by the fact that in southern Michigan *occulta* seldom emerges before late June and early July, when the surface waters of the lake are generally so warm as to repel trout. It should be stated, in this connection, that terrestrial insects were of very rare occurrence in the stomachs except during October and early November.

On a volumetric basis, the rainbow trout diet in Birch Lake was made up of the following major categories of food items: fish, 43 per cent; aquatic insects, 23 per cent; vegetable matter, 6 per cent; mollusks, decapod crustaceans and terrestrial insects (87 species of the last-named), 3 per cent each. The remaining 19 per cent was composed of unseparated organic debris and of negligible numbers of entomostracans, water mites and spiders. The aquatic insect portion of the stomach contents is detailed in Table I. The catholicity of a diet so comprehensive as to embrace 170 species of invertebrates alone makes it appear likely that the rainbow trout is almost wholly opportunistic in its feeding. It seems obvious that throughout all seasons nymphs of *H. occulta* in Birch Lake were so readily available to the trout as to almost equal, in the diet, the volume of all other aquatic insects combined, whereas, with minor exceptions, nymphs of *E. simulans* became available only during the brief period of their migration to the lake's surface to transform. The fact that *H. occulta* appears to have a two-year life cycle and *E. simulans* an annual cycle in southern Michigan cannot explain the disparate occurrence of the two species, for stomach collections made over a period of six years and a seasonal span of seven months were examined. In the absence of recorded observations on the behavior of nymphs of the two species in their natural habitat it appears justifiable to conclude that *E. simulans* spends its nymphal life too deeply embedded in the substrate to be available to bottom-feeding rainbow trout and that *H. occulta* nymphs, on the other hand, either leave their burrows occasionally or at least come near enough to the surface of the lake bottom to fall a consistent prey.

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NEW NORTH AMERICAN BEES OF THE GENUS DUFOUREA

(Apoidea: Halictidae)

PART I

GEORGE E. BOHART,
Formerly of the University of California

The number of known species of North American *Dufourea* has increased rapidly in recent years. In 1937 C. D. Michener[1] raised the number of valid described species from 20 to 26. P. H. Timberlake in 1939[2] and 1941[3] added 14 species. T. D. A. Cockerell[4] in 1941 added one from Lower California. The following seven new species plus eight more which will be described in the next paper of this series, will bring the total number of species to 56.

Males of all species of *Dufourea* can be readily recognized. Facial measurements, antennal proportions and pubescence, and modifications of the legs and sternites present the most striking characters. Females conform rather closely to a common pattern and in related species they are often difficult to separate. For a few pairs of related species no consistent characters of differentiation have been found.

The following descriptions have been made rather detailed in view of the large number of species in the genus and the lack of any adequate system of subgenera. Moreover, it is hoped that the species herein described may be recognized for the present without complete tables for separation and that the characters described will serve as guides for further studies in the genus.

Holotypes and allotypes of species described in this paper will be deposited at the California Academy of Sciences in San Francisco. Paratypes will be distributed to the following collections besides the author's: U. S. National Museum; U. C. Citrus Experiment Station, Riverside, California; American Museum of Natural History, New York. When available, paratypes will be sent to other collections upon request.

Dufourea gilia n. sp.

Male.—Length about 6 mm., length of anterior wing 3.4 mm.; pubescence wholly pale, mostly white; integument dark with bluish reflections distinct only on head. *Head:* Face length to breadth 95–90; eyes distinctly convergent below, the distance between them at antennal insertion slightly less than eye length; face viewed from front with distance behind posterior ocellus nearly equal to ocellar diameter; no concavities behind or laterad to ocelli; distance from antennal socket to clypeus one half again as great as socket diameter; clypeus, supra-

[1]Ann. & Mag. Nat. Hist. (10) 19, pp. 328 and 393–401.
[2]Ann. Ent. Soc. Amer. 32, pp. 395–414.
[3]Ann. Ent. Soc. Amer. 34, pp. 38–42.
[4]Trans. San Diego Soc. Nat. Hist. 9, p. 347.

clypeal area concealed by dense, white, reclining pubescence; punctures of frons moderately fine, close, mostly little less than one puncture width apart, absent from area laterad to posterior ocellus; antennae black, as long as anterior wing, flagellar segments mostly about half again as long as broad, the first three-fourths as long as second, all entirely roughened, slightly expanded medially and with many pale, hooked hairs about half as long as flagellar width and confined to under side but not to definite rows; scape a little over twice as long as broad, with long inner and short outer hairs; maxillary stipes one seventh longer than hind tibia, the galea beyond palpus nearly four times as long as broad, apically attenuate; maxillary palpus longer than hind tibia, the second segment nearly twice as long as first and as long as next three combined; labial palpus three-fourths as long as maxillary, the first segment equal to next two combined. *Thorax:* Mesoscutum and mesoscutellum strongly, moderately closely punctured, the punctures mostly a little more than one puncture width apart; area between punctures polished; mesoscutal hair both long and short, not at all concealing integument; mesoscutellar pubescence dense and mostly about as long as scape; wings definitely yellow-tinged, first transverse cubital vein offset from first recurrent by two-thirds its own length; legs not highly modified; femora slightly swollen, fore and mid ones broadest near base, the former with hair fringe longer than scape; hind tibia decidedly swollen beyond middle, over one-third as broad as long, swollen portion with pubescence two-thirds as long as tibia; mid tibia strongly swollen near apex where it is twice as broad as at base, and with outer face covered by long, dense pubescence; hind metatarsus parallel-sided, nearly four times as long as broad, the succeeding three segments about as broad as long. *Propodeum:* Enclosure coarsely rugo-carinate throughout, with about 12 rugae on either side of mid line. *Abdomen:* Tergites finely, sparsely punctate, first segment mirror-like but with rather numerous scattered punctures on middle half; apical fascia long, complete on apical four segments but not so dense as in *tuolumne*; last three tergites with numerous scattered white hairs between fascia, lateral pubescence of sixth longer than the segment; sternites without lateral hooklets; fifth emarginate apically, the emargination broadly truncate medially, mid line swelling almost imperceptible; sixth with median elevated ridge very similar to that of *tuolumne*; posterior arms of seventh slender, narrowly rounded apically, with short hair; apical projection of eighth slender but broadened in profile.

Female.—Length about 5 mm.; length of anterior wing 4 mm.; pubescence whitish, somewhat tinged with yellow on dorsum of thorax; integument black, with feeble bluish reflections on frons; body robust. *Head:* Face nine-tenths as broad as long; inner eye margins parallel, distance between them at antennal insertions equal to eye length; distance from antennal socket to clypeus greater than socket diameter; face, viewed directly from front, with postocellar length less than ocellar diameter; anterior face of clypeus with about 30 coarse punctures, most of them sublateral; hair of clypeus sparse, semi-erect, that of supraclypeal area dense, reclining; frons with numerous short hairs visible mainly in profile; frons evenly convex, with punctures about one

puncture width apart except for impunctate area laterad to posterior ocellus; antennal flagellum black. *Thorax:* Dorsum rather dull, strongly punctured, the punctures generally not more than one puncture width apart; mesoscutum with only very short yellowish pile, conspicuous in lateral aspect; mesoscutellum and metanotum largely obscured by dense, yellowish hair; hind wing with 5 hamuli; apical bristles of fore tibia testaceous; mid tibial spur testaceous to whitish; tibial scopa moderately dense, whitish, the hairs somewhat appressed. *Propodeum:* Enclosure coarsely rugo-carinate (crinkly), with strong posterior transverse carinae. *Abdomen:* Tergites with fine, mostly setigerous punctures, the first segment mirror-like but with several hundred tiny punctures on dorsal disk; whitish apical borders of tergites three and four with complete but not dense hair bands; basal hair border of tergite three complete, well defined; anal fimbria reddish testaceous.

Holotype male, *allotype*, 3 male *paratypes:* 16 miles east of Mt. Hamilton, Santa Clara Co., California, April 20, 1947, from *Gilia* (G. E. Bohart).

The only variation noted in the series was a slight increase in the density of the abdominal hair bands over the holotype.

This species is very close to *D. tuolumne* new species but has a decidedly longer face in both sexes and more dilated hind tibia and metatarsus in the male.

Dufourea tuolumne n. sp.

Male.—Length about 5 mm., length of anterior wing 3.1 mm.; pubescence wholly pale, mostly white; integument dark with bluish tints, especially on head. *Head:* Face slightly broader than long; eyes rather strongly converging below, distance between them at antennal insertion no greater than eye length; face, as viewed directly from in front, with distance from posterior ocellus to posterior vertex margin negligible, less than half an ocellar diameter; no concavities behind or laterad to ocelli; distance from antennal socket to clypeus slightly greater than socket diameter; clypeus, supra-clypeal area concealed by dense, white, reclining pubescence; punctures of frons moderately fine, close, mostly a little less than one puncture width apart, absent from small area just alterad to posterior ocellus: antennae black, long, reaching at least to metanotum, the flagellar segments mostly a little more than half as broad as long, entirely roughened, non-crenulate, the second slightly longer than first or third, all segments with more than ten (many with more than twenty) pale hooked hairs, less than half as long as flagellar width, confined to under side but not to definite rows; scape slightly more than twice as long as broad, inner hairs long, outer ones short; maxilla with stipes shorter than posterior tibia, no longer than eye; galea three times as long as broad, pointed apically; maxillary palpus over half as long as stipes, first segment not more than three times as long as broad, three-fourths as long as second, both together longer than next four (which are sub-equal) together; labial palpus nearly as long as maxillary, first segment five times as long as broad, longer than succeeding two together, second slightly longer than fourth, nearly twice the third. *Thorax:* Mesoscutum strongly, moderately closely punctured, the punctures mostly about or a little more than

one puncture width apart mesoscutellum more densely punctate; area between punctures shining, non-reticulate; mesoscutum with rather sparse, fine, wholly white hair never concealing integument, often moderately long; metanotum, mesoscutellum with dense pubescence as long as antennal scape; wings clear, faintly clouded with yellow, first transverse cubital vein offset from first recurrent by its own length; legs not conspicuously modified; femora slightly swollen, about twice as long as broad, anterior, middle ones broadest near base, the former with fringe of hairs nearly as long as femur; fore, mid tibiae with short, uniform pubescence, hind one swollen just beyond the middle, less than three times as long as broad, with fringe of hairs sometimes longer than tibia; fore basitarsus with very long hairs, longer than itself, mid basitarsus distinctly arcuate, with similar hair fringe to fore one; hind basitarsus three times as long as broad, succeeding two segments longer than broad, penultimate one broader than long. *Propodeum:* Enclosure coarsely rugo-striate, medially rugose with about eight comparatively distinct acrinae on either side of mid line, the sculpturing no weaker posteriorly. *Abdomen:* Tergites sparsely, finely punctured, numerous but separated by several puncture widths because of their minute size, sparsest on first tergite; all tergites with distinct, long, apical fasciae, the basal two strong laterally only, those of fourth, fifth tergites, when abdomen is not extended, nearly half as long as visible sternite portions; tergites with white hair between fasciae, prominent laterally on last three; sternites without lateral hooklets; fifth sternite slightly raised along mid line, emarginate apically, the emargination truncate medially; sixth sternite with median, longitudinal, colorless transparent, elevated area, broadest sub-basally, narrowing, increasing in height posteriorly, forming a terminal, sharp ridge running along mid line of the short, flat sternite projection; posterior arms of seventh narrowed most of their length, apically acute, with hairs confined to apices, basal ventral flaps considerably broader than long; apical process of eighth sternite broadest just basad to middle, narrow for apical third, slightly expanded at apex to one-half greatest breadth, hairs of base of narrow portion three times as long as at apex.

Female.—Length about 5 mm., length of anterior wing 3.8 mm., pubescence white to pale brown, short, abundant; integument black with metallic bluish tinge on head, slight purplish copper tinge on mesoscutum; body robust. *Head:* Face slightly less than six-sevenths as long as broad; inner eye margins nearly parallel, slightly converging below, their length not quite so great as distance between them at antennal insertion. Face, as viewed directly from in front, with distance from a posterior ocellus to posterior vertex margin not more than half an ocellar diameter; distance from antennal socket to clypeus nearly as great as socket diameter; clypeus uniformly but very sparsely, coarsely punctate, fringed basally with pale brown hairs; frons strongly convex in profile, uniformly covered with fine, short pubescence, dense but not distinct except in profile, surface very uniformly punctate, the punctures moderately strong, separated by distinctly less than one puncture width; antennal flagellum black. *Thorax:* Mesoscutum dull, finely, rather closely punctured, the punctures much as on frons, a little finer, denser anteriorly; mesonotum densely covered with very short,

fine, pale brownish hair, conspicuous only from lateral view, these interspersed with a few darker brown hairs as long as an ocellar diameter; apical bristles of fore tibia testaceous; mid tibial spur testaceous to whitish, apical two fifths with about eight needle-like teeth, basal portion apparently edentate; tibial scopa moderately dense, pale brownish, hairs mostly somewhat appressed. *Propodeum*: Enclosure coarsely, irregularly rugose, rugae becoming straighter laterally. *Abdomen*: Tergites with fine punctures, mostly setigerous, except on first where they are typically punctiform but very thiny, separated by several puncture widths; apical tergite borders testaceous; hair distinct, whitish, nearly complete, often nearly concealing impunctate tergite borders; remainder of tergum with pale, short hair, conspicuous as viewed laterally; anal fimbria bright testaceous. *Holotype:* Tuolumne Co., California, elevation 3500 ft., June 9, 1938, from *Linanthus filipes*, (R. M. Bohart). *Allotype:* Same as for holotype. *Paratypes:* 38 males, 15 females, same data as for holoytpe (some collected by N. F. Hardman). Very little variation is observable. The closeness of mesoscutal punctures is slightly but not significantly variable.

This species is related to *californica* (Mich.) and *linanthi* Timb. It can be easily distinguished by the high carina of the sixth sternite and the arcuate mid basitarsus of the male.

Dufourea vanduzeei n. sp.

Male.—Length about 6 mm.; length of anterior wing 3.4 mm.; pubescence wholly pale, mostly white; integument dark with bluish reflections distinct on head, almost imperceptible on thorax; body slender. *Head:* Face nine-tenths as long as wide; eyes rather strongly converging below, the distance between them at antennal insertions a little less than eye length; face, viewed from in front, with postocellar distance subequal to ocellar diameter; areas behind and laterad to ocelli without concavities; distance from antennal socket to clypeus slightly less than socket diameter; clypeus, and to lesser extent supraclypeal area concealed by dense, white, reclining pubescence; punctures of frons rather fine and sparse, averaging at least two puncture widths apart, absent from crescentic area just laterad to posterior ocellus; antennae blackish, as long as anterior wings, the terminal 5 segments distinctly lobate, the others less so; under sides of flagellum with very numerous tiny erect hairs bent at the tips and conspicuous in profile compared to the minute reclining pubescence of the "bare" remainder; first flagellar segment a little longer than broad, over two-thirds as long as second, two-thirds as long as third which is nearly twice as long as broad; scape three times as long as broad, mostly parallel sided; maxillary stipes three-fourths as long as posterior tibia, the galea beyond palpus half as broad as long; maxillary palpus three-fifths as long as stipes, segments one and two subequal, each as long as segments three, four and five combined; labial palpus about four-fifths as long as maxillary, the first segment subequal to the others combined. *Thorax:* Mesoscutum strongly but not closely punctured, the punctures averaging about two puncture widths apart; interpunctural areas subshining, slightly reticulate; mesoscutum rather densely covered with long yellowish pubescence, partially obscuring the integument in lateral view;

mesoscutellum and metanotum more densely clothed with longer hair of the same color; wings faintly yellowish, the first transverse cubital vein offset from first recurrent by two-thirds its own length; legs slender; metatarsi parallel sided, from four to six times as long as broad; hind tibia four times as long as broad, polished, with hair of dorsal margin nearly as long as tibial breadth; second and third hind tarsal segments longer than broad; hair of hind metatarsus about as long as tarsal width. *Propodeum:* Enclosure coarsely rugo-carinate, about 10 major carinae on either side of mid line; posterior margin of enclosure with a single transverse ridge. *Abdomen:* Tergites with fine but numerous punctures; apical hair bands well defined, complete on all segments; tergal pubescence otherwise abundant, yellowish, partially obscuring integument from lateral view; first five sternites without hooklets but with well defined postero-lateral hair bands; apex of sternite five evenly emarginate; sternite six with a broad oval median glabrous plate produced apically into a keel-like projection which is also produced from the posterodorsal margin of the sternite; posterior arms of sternite seven broad, flat, nearly pointed apically with long, dense terminal hair tufts; posterior projection of sternite eight slender throughout, nearly as broad at apex as at base. *Holotype* male and *paratype* male: Bryson, Monterey Co., California, May 19, 1920 (E. P. Van Duzee); also one damaged male (abdomen missing) with the same collecting data. The holotype has part of the ventral margin of the projection on sternite six and the inner margins of the arms of sternite seven chewed away (presumably by psocids). Otherwise it checks in detail with the paratype.

This species appears to be in the *D. californica* Michener group and falls closest to *D. tuolumne* new species but is easily distinguished by its larger size, broader median plate on the sixth sternite; shorter face, and more slender legs.

Dufourea neocalifornica n. sp.

Male.—Length about 7 mm.; length of anterior wing 5 mm.; integument dark with dark blue and some coppery reflections; pubescence pale, mostly white. *Head:* Face four-fifths as long as wide; eyes rather strongly converging below, their length a little shorter than distance between them at antennal insertions; face, viewed from in front, with postocellar distance about half an ocellar diameter; area between eyes and posterior ocellus not depressed; distance from antennal socket to clypeus greater than socket diameter; clypeus closely punctate, concealed by dense, reclining pubescence; supra-clypeal area bare (perhaps abraded), polished, practically impunctate; frons densely punctate except along inner eye margins and laterad to posterior ocelli, mostly less than one puncture width apart; antennae black, long, at least four-fifths as long as anterior wing, most of the segments distinctly lobate; scape about twice as long as wide; first flagellar segment two thirds as broad as long, three-fourths as long as second which is slightly longer than succeeding segments except terminal one; under side of flagellum rather flat, bearing mat of numerous short hooked hairs, over 20 on most segments and about one-third as long as flagellar width; maxillary stipes about three-fourths as long as posterior tibia; galea beyond palpus slightly more than twice as long as broad, almost pointed apically;

maxillary palpus three-fourths as long as stipes, first segment four-fifths as long as second, the two together as long as next four combined; labial palpus five-sixths as long as maxillary, the first segment three-fourths as long as next three combined. *Thorax:* Mesoscutum closely, strongly punctured, the punctures less than one puncture width apart, the interpunctural areas shining; mesonotum rather densely clothed with long yellowish pubescence, somewhat obscuring integument from lateral view; wings faintly yellowish, the first transverse cubital vein offset from first recurrent by slightly over half its own length; legs rather stout but not strongly modified; femora about twice as long as broad; hind tibia nearly one-third as broad as long, broadest just beyond middle, with hairs of inner margin not longer than tibial width; mid metatarsus depressed above near base; hind metatarsus half as long as tibia, two-fifths as broad as long, the next two segments produced dorsally, broader than long. *Propodeum:* Enclosure coarsely, evenly carinate, a straight line drawn transversely across the middle cutting about twenty-five carinae. *Abdomen:* Tergum shining but with numerous well defined punctures; tergite one with at least 100 well defined punctures on disk; apical hair bands white, well defined, contrasting strongly with remaining short brown tergal pubescence; sternum shining, with only minute pubescence, lacking hair bands except at corners; sternite five slightly elevated medially and rounded apically; sternite six with a triangular projection a little longer than broad, bearing a median ridge with a strong apical summit, the projection glabrous except for a short stiff lateral fringe; posterior arms of sternite seven evenly tapered, narrowly rounded apically; apical projection of sternite eight slender, with tip about twice as broad as narrowest part and less than half as broad as broadest part.

Holotype (unique): Sequoia National Park, California, elevation 2000–3000 ft., May 1930 (collector unknown).

This is very close to *D. californica* (Michener) but differs by having a pronounced apical summit on the projection of the sixth sternite and lacking a pair of strong sublateral hair tufts on the same segment.

Dufourea tarsata n. sp.

Male.—Length (abdomen extended) about 9 mm., length of anterior wing 5.2 mm., pubescence wholly whitish; integument dark, with distinct metallic bluish tint to head, thorax, dorsum of abdomen. *Head:* Face as long as broad; eyes converging slightly below, distance between them at antennal insertion about equal to eye length; face viewed from front with distance from posterior ocellus to vertex margin somewhat greater than ocellar width; area laterad to posterior ocellus shallowly concave; distance from antennal socket to clypeus about equal to socket diameter; clypeus with erect, white pubescence long basally, grading down to short apically, except for marginal fringe; supra-clypeal area bare except for sparse lateral tuft; punctures of frons fine, rather dense laterally, very sparse medially and just laterad to ocelli; area enclosed by subantennal sutures entirely impunctate; antennae black, short, non-crenulate, ventrally flattened, basally swollen; basal two flagellar segments slightly cupped beneath, with dense curled pubescence, the remaining segments with ventral surfaces bearing rather dense mats of

curled hairs mostly about as long as antennal width; first flagellar segment as broad as long, longer than second which is longer than third which is nearly twice as broad as long; scape globose, about three-fourths as broad as long, covered with long white hair; maxilla with stipes practically as long as hind tibia, galea less than three times as long as broad; maxillary palpus a little shorter than eye, first segment about twice as long as broad, about three-fourths as long as second, oth together shorter than next three together which are subequal; labial palpus a little longer than first four maxillary palpal segments; the first segment four times as long as broad, slightly longer than second which is slightly longer than either of last two. *Thorax:* Mesoscutum strongly, moderately closely punctured, the punctures between one and two puncture widths apart; mesoscutellum more densely punctate; interpunctural areas polished; mesoscutum with long, rather sparse hair not at all concealing integument; wings with yellowish tinge, the first transverse cubital vein offset from first recurrent by nearly its length; legs somewhat swollen; femora about half as broad as long, broadest medially; mid tibia about half, hind tibia about two-fifths as broad as long, broadest near apex; mid metatarsus about half, hind metatarsus nearly two-thirds as broad as long, succeeding segments of hind tarsus broader than long, strongly projecting dorso-apically. *Propodeum:* Enclosure strongly, closely carinate, about 15 carinae on either side of midline; posterior margin with three strong transverse carinae. *Abdomen:* Tergum with very fine sparse punctures, first segment mirror-like, practically impunctate; apical hair bands rather sparse, not concealing integument, that of apical segments no stronger than other hair; fourth sternite with a pair of recurved hooklets near posterior margin; fifth gently rounded medially; sixth with flat, testaceous, truncate apical projection about as long as broad, and covered with a short, dense tuft of testaceous hair; posterior arms of seventh broad to near their acute apices, the basal ventral flaps about two-thirds as long as remainder; apical process of eighth about three times as long as basal breadth, slightly expanded at apex.

Female.—Length 7 mm.; length of anterior wing 5 mm.; pubescence white to testaceous, rather sparse, not obscuring integument which has dark bluish and coppery reflections. *Head:* Face as long as broad; inner eye margins parallel; eye length six-sevenths interocular width at insertion of antennae; when viewed from in front, distance from posterior ocellus to vertex about equal to ocellar diameter; frons with broad shallow concavity laterad to posterior ocellus; distance from antennal socket to clypeus about two-thirds socket diameter; clypeus with about 30 coarse punctures and about as long as width between inner bases of teeth on apical margin which bears tawny hairs as long as clypeus; punctures of frons separated by about one puncture width except near ocelli; facial vestiture light testaceous, sparse; antennal flagellum partially dull brownish yellow on apical five segments. *Thorax:* Mesoscutum and scutellum shining, uniformly covered with fine punctures from one to two puncture widths apart, and with vestiture composed of numerous short hairs and a few scattered long ones, which together do not obscure integument, even from lateral view; hind wings with 7 hamuli; apical bristles of fore tibia testaceous; mid tibial spur reddish

testaceous throughout; tibial scopa whitish, moderately appressed; hind tibia and metatarsus each about four times as long as broad. *Propodeum:* Enclosure coarsely carinate, with about 20 carinae on either side of mid line and a few transverse carinae near posterior border, followed by a non-carinate slightly roughened area. *Abdomen:* Tergites with very fine, mostly setigerous punctures, first segment mirror-like, with about 75 minute punctures on dorsal disk; apical tergite borders transparent, not at all concealed by sparse hair fringes; anal fimbria reddish testaceous.

Holotype male, *allotype*, 6 *paratype* males and 4 *paratype* females: 16 miles east of Mt. Hamilton, Santa Clara Co., California, elevation 2000 ft., April 20, 1947, from *Gilia* (G. E. Bohart).

Some of the females differ from the allotype in being smaller and having wholly dark antennae.

This is very closely related to *D. sandhouseae* Michiner but is easily distinguished in the male by the bare, impunctate area enclosed by the subantennal sutures and by the more swollen mid and hind tarsi. The female is somewhat larger than *sandhouseae* and has a slightly narrower face. Certain females of the two species are probably indistinguishable morphologically.

Dufourea timberlakei n. sp.

Male.—Length about 7 mm.; length of anterior wing 5 mm.; pubescence white, long, sparse; integument black without bluish or greenish reflections; last 10 flagellar segments yellow on outer sides. *Head:* Face ten-elevenths as long as broad; eyes slightly convergent below, their length six-sevenths as great as distance between them at antennal insertions; clypeus over twice as broad as long, densely punctured, covered with reclining white pubescence except for basal bare, impunctate strip; distance from antennal socket to clypeus about two-thirds socket diameter, half distance between sockets; cheek between antenna and base of mandible with patch of long brown hair; frons irregularly, sparsely punctate, the punctures averaging over one puncture width apart, nearly impunctate on broad, slightly concave area laterad to posterior ocellus; antennae short, scarcely over one-third length of anterior wing; scape at least half as broad as long; first flagellar segment broader than long, about three-fourths as long as second which is slightly longer than any of remaining segments; flagellum bare except for usual minute general pubescence; maxilla with stipes slightly shorter than hind tibia, galea less than half as long as stipes, rounded apically; maxillary palpus about two-thirds as long as stipes, first segment less than four times as long as broad, about three-fourths as long as second, as long as fourth and fifth together; labial palpus a little over half as long as stipes, first segment one and one-half times as long as second or third and fourth combined. *Thorax:* Mesoscutum rather sparsely punctate medially where many punctures are two or three puncture widths apart; punctures of mesoscutellum, sides of mesoscutum one to two puncture widths apart; dorsum, sides of thorax covered with long, sparse pubescence, mostly as long as scape, largely hiding short mesoscutal pubescence; wings slightly yellowish, the first transverse cubital vein offset from first recurrent by two thirds its own length; legs rather

stout but not highly modified; fore and mid femora half as wide as long; hind tibia evenly tapered, about three times as long as broad, with many hairs of inner margin two-thirds tibial length; metatarsi about four times as long as broad, parallel sided; second, third, fourth hind tarsal segments each about as long as broad. *Propodeum:* Enclosure strongly, evenly carinate, a straight transverse line drawn through middle cutting about 35 carinae. *Abdomen:* First tergite nearly impunctate on disk but subshining and reticulate, not mirror-like; remaining tergites with apical hair margins weakly defined laterally, not differentiated dorsally from semi-erect brownish tergal pubescence; sternum with first five segments rather densely covered with short, erect hair; fourth with a pair of tiny sublateral thorn-like projections; apical margin of fifth gently convex medially; sixth with a broad median circular depression and a short, broad, gently emarginate apical process, the depressed area bare, twice as broad as long, the process with rather long marginal hair ventrally; posterior arms of seventh about two-fifths as broad as long and evenly tapered, with apex rounded and margined by long hairs; posterior projection of eighth with apex twice as broad as narrowest, half as broad as broadest parts.

Holotype male and two *paratype* males: Mt. Pinos, Ventura Co., California, May 31, 1942 (R. M. Bohart).

This is closest to *D. truncata* Timberlake but is larger, has a broader, less thickened process of the sixth sternite, a brown patch of hair above the sides of the clypeus, and no metallic blue color on the frons. One of the paratypes differs from the type in having a largely impunctate area in front of the median ovellus and scattered large punctures in the areas laterad to the lateral ocelli. Both paratypes have a more polished first abdominal tergite than has the type.

Dufourea femorata n. sp.

Male.—Length about 11 mm., length of anterior wing 7 mm.; integument black with no tinge of blue, green, or copper; pubescence pale except for some black facial hair; body elongate. *Head:* Face a little broader than long; inner eye margins approximately parallel, slightly converging below, distance between them at antennal insertion slightly greater than eye length; face, as viewed directly from in front, with distance between posterior ocelli not greater than from one of them to posterior margin of vertex; distance from antennal socket to clypeus as great as socket diameter; area between posterior ocellus and upper margin of eye distinctly depressed; clypeus concealed by a long, white, dense, reclining tuft of hair extending beyond clypeus a distance equal to clypeal length, and with a few erect black hairs at its base; supraclypeal area distinctly but sparsely punctate, with white, prostrate hair bounded laterally by long, erect, black hair extending upwards along inner eye margins; frons moderately coarsely, irregularly punctate, the punctures nearly contiguous except along eye margins and posterior to median ocellus where they are frequently separated by one or more puncture widths; antennae rather short, reaching about to tegulae, the flagellum black, not at all clubbed, slightly crenulate, the segments, as viewed from above, slightly longer than broad, the second but little longer than first or third, shorter than last; flagellar hairs pale brown to

whitish, as long as flagellar width, strongly bent near their middles toward flagellar apex, never more than three per segment, confined to first nine segments; scape over twice as long as broad; maxilla with stipes nearly one-third its length longer than eye, about as long as posterior tibia; galea a little less than three times as long as broad, narrowly rounded apically; maxillary palpus nearly four-fifths as long as stipes, first segment three times as long as broad, four-fifths as long as second, approximately equal to each of remaining segments; labial palpus three-fourths as long as maxillary, first segment five times as long as broad, a little longer than second maxillary palpal segment or second labial, one-third its length longer than third or fourth labial. *Thorax:* Mesonotum uniformly, moderately closely, coarsely,punctured, the punctures averaging a little less than one of their diameters apart except on median line, surface sparsely covered with long, white and a few brown hairs, some short, white pubescence; wings clear but distinctly stained with brownish yellow, the second transverse cubital vein separated from second recurrent by half its own length; legs strikingly modified; femur nearly as broad as long, produced ventrally at the middle to an angle of somewhat greater than 90 degrees; mid tibia one-third as broad as long, broadest apically, where it overhangs base of tarsus; mid tibial spur strongly curved; mid metatarsus greatly flattened, elongated, with a large, flat, semi-lunar, ventral production whose apex is directed distally, the segment being half as broad as long with its base having a small, inner, knot-like hump from which springs a dense tuft of stiff hairs; posterior femur with a strong, ventral, blunt, spine-like projection at its middle, directed at right angles to tibial axis, causing the segment to be as broad as long; posterior tibia arcuate, over one-third as broad as long, with a rather long brush of white hairs on outer apical half and a ridge of very long white hairs along inner ventral margin; posterior metatarsus nearly twice as long as remainder of tarsus, more than one-third as broad as long, polished on its outer surface; remaining tarsal segments, except the last, strongly produced posteriorly, over twice as broad as long. *Propodeum:* Enclosure completely, strongly carinate, the carinae rather even and parallel, the inter-carinal spaces no broader than carinae. *Abdomen:* Tergites finely, sparsely punctate, those on first tergite minute, many puncture widths apart and on next two more abundant, especially basally; white hair bands distinct but sparse; median hair of tergites brownish; third with apical lateral corner slightly projecting; fourth with a pair of strong, recurved hooklets just inside apical lateral corners, connected by low ridges with small ventrally directed teeth at the extreme corners; fifth emarginate apically, the emargination truncate medially; sixth with a convex, laterally impressed, median, longitudinal area, slightly broadened sub-apically, entirely covered with a short, fine, dense pad of hair, and terminating apically in a weakly bilobed, flat projection which extends slightly beyond sternite proper; dorsally placed under the apex of this area is a flat, rounded apical lobe, twice as long as broad, as long as mid line of sternite proper and covered with a dense, long tuft of white hair; posterior arms of seventh nearly three times as long as their basal, ventral flaps, carinate laterally, apically surrounded with dense yellow pubescence less than one-third as long as the arms; apical projec-

tion of eighth basally broadened, narrowest at middle, remaining parallel sided to apex which is less than one-fifth as broad as base.

Female.—Length about 11 mm., length of anterior wing 6.5 mm.; pubescence mostly pale; integument black as in male; body slightly elongate. *Head:* Face almost precisely as long as broad (a minute fraction broader); inner margins of eyes essentially parallel, the distance between them at antennal insertion somewhat greater than eye length; face, viewed directly from in front, with distance from posterior ocelli to posterior margin of vertex three-fourths that between them; distance from antennal socket to clypeus slightly less than socket diameter; clypeus coarsely, moderately densely punctate, the punctures, except on apical margin, little more than one of their diameters apart; hair of clypeus, inner eye margins, frons dark brown, that of antennal scapes, area between them with long white hairs mixed with a few dark ones; frons moderately strongly, densely punctate, the punctures between lower two-thirds of eyes and along entire inner eye margins mostly separated by one to two puncture widths, those of areas behind ocelli and between lateral ocellus and compound eye mostly less than one width apart; antennae black. *Thorax:* Elevated posterior portion of pronotum long laterally but nearly obsolete medially, the lateral margins with dense white hair tufts; mesonotum uniformly, rather finely, closely punctate, the punctures mostly separated by about one of their diameters; mesonotal surface provided with only a few long, dark brown hairs, and very few short ones except for microscopic pubescence scarcely protruding beyond punctures; apical bristles of fore and mid tibiae testaceous; mid tibial spur testaceous; about twelve times as long as broad, rather strongly curved at apex, with over fifteen small teeth having needle-fine apices, the apical sixth of spur edentate; tibial scopa rather dense, white, appressed, with a fringe of brownish hairs along upper margin. *Propodeum:* Enclosure coarsely, uniformly carinate, the carinae diverging posteriorly; a straight transverse line drawn through middle of enclosure cutting from twenty to twenty-five carinae. *Abdomen:* Tergites distinctly punctured, the first very sparsely, the punctures being several to many of their diameters apart; second tergite more closely punctured but with punctures two or more diameters apart; impunctate tergite borders testaceous; abdominal hair bands no longer than tergite borders, the first two incomplete; median hair of tergites dark brown; anal fimbria dark testaceous; apical tergite with distinct median, longitudinal carina.

Holotype male and *allotype:* Tuolumne Co., California, elev. 3500 ft., June 9, 1938, from *Gilia capitata*, (R. M. Bohart); *Paratypes:* 5 males, 36 females, same data; 7 males, 1 female, Marsh Creek Springs, Contra Costa Co., California, April 26, 1937, from *Gilia tricolor*, (G. E. Bohart, R. M. Bohart, C. D. Michener); 3 males, 4 females, same place and host, May 21, 1938, (G. E. Bohart, R. M. Bohart); 1 male, Butte Cr., near Chico, Butte Co., California, April 25, 1922, (Helen Van Duzee); 1 male, Antioch, Contra Costa Co., Calif., May 18, 1936, (M. A. Cazier); 1 male, Mt. Hamilton, Santa Clara Co., California, April 26, 1913, (J. C. Bridwell).

Variation is slight in this species. The first transverse cubital and first recurrent veins are sometimes nearly contiguous. The size of the

relatively impunctate areas of the frons is also somewhat variable. Body size is often smaller than that described for the holotype.

This is easily distinguished from all except *D. virgata* (Ckll.) by its large size, dense punctures, flattened face, and pale pubescence in both sexes, and in the male by its peculiar leg characters. It can be told from *D. virgata* by its larger size, finer propodeal sculpturing, and the reversed condition in degree of production of mid and hind femora.

REVIEW OF THE WEEVILS OF THE TRIBE OPHARYASTINI OF AMERICA NORTH OF MEXICO, by A. C. Davis. Proceedings of the United States National Museum, Vol. 96, No. 3207, pages 483–551, 1947.

While all taxonomists must sometimes publish descriptions of new species, reviews and revisions have seemed to the reviewer a far more valuable contribution to the literature of entomology. It is regrettable that the death of the author brought his work on the weevils to an untimely end, for he had evidently made much sound progress toward the comprehensive revision of difficult groups. Fortunately this portion of his work was sufficiently advanced to be prepared for publication by L. L. Buchanan, himself an expert in the taxonomy of the weevils.

The article includes keys to genera, groups and species, and in some cases the species are keyed by genitalic structure as well as by superficial characters. The treatment of species includes ample descriptions, notes on geographic distribution and comparative notes, with brief references to the bibliography. The genitalia of many species are illustrated by text figures. Two Mexican species are included, but according to Mr. Buchanan's footnote the study of Mexican species in general was not sufficiently advanced to permit the treatment of all of them in this publication.—A. W. L.

PULGAS, BIBLIOGRAFIA, CATALOGO E HOSPEDADORES, by A. da Costa Lima and C. R. Hathaway. Monografias do Instituto Oswaldo Cruz, No. 4, 522 pages, December, 1946. Rio de Janeiro, Brazil.

The difficulties experienced by the authors in their work on neotropical fleas led them to undertake the preparation of this catalogue, which covers the fauna of the entire world. It is an ample and well organized work which should be of great value to specialists in the order.

The first section of the catalog is a bibliography occupying sixty-six pages. It may prove inconvenient since the arrangement is chronological instead of alphabetic, but the listing of such a wealth of published material cannot fail to be helpful. The bibliography is followed by a taxonomic index. The catalog proper fills two hundred forty-four pages. Under the ordinal name Suctoria an extensive synonymy and bibliography are followed by the usual catalog treatment of the subordinate divisions and species. Genotypes are cited and the synonymy of both groups and species is apparently fully covered. Numerous references to the literature are given in addition to those in which names were originally proposed. Additional material consists of the distribution of species and a list of the host species. The catalog is followed by a taxonomic list of host species, each entry including a list of the parasites recorded from that host. An excellent general index covers all of these parts, listing alphabetically the names of authors, host species and all taxonomic categories.

The reviewer is constantly impressed with the labor involved in the preparation of adequate catalogs. As compared with revisional studies they seem unrewarding to their authors. We can only hope that the authors are fully aware of the service that they render to other entomologists and of the appreciation that others must feel for their help.—A. W. L.

THE IDENTITY OF THE PHLEBOTOMUS ASSOCIATED WITH BARTONELLOSIS IN COLOMBIA

LLOYD E. ROZEBOOM[1]

During 1935 an outbreak of Oroya fever occurred in southeastern Colombia. The history of the epidemic was reviewed by Brumpt and Brumpt (1942) and Jaramillo (1943), who investigated its epidemiology in Colombia; these authors concluded that the disease was introduced into this region, perhaps by returning soldiers or by the "colporteurs" who travel from village to village. With the aid of Dr. Osorno a number of *Phlebotomus* were taken in the epidemic zone; these insects were studied by Ristorcelli and Van Ty (1941 a and b), who identified them as *P. longipalpis*, *P. evansi*, *P. osornoi* n. sp., *P. colombianus* n. sp., and *P. monticolus* var. *incarum* n. var.

In 1943 I received from Colombia a small series of *Phlebotomus* females which I provisionally identified as *P. verrucarum;* however, the accuracy of this identification became especially doubtful with the receipt of the 1945 Annual Report of the Gorgas Memorial Laboratory, in which Hertig noted that he was unable to find any Peruvian *Phlebotomus* in Colombia. When the descriptions by Ristorcelli and Van Ty were obtained it became evident that the specimens I had received had been described by these authors as *colombianus* and *incarum*.

Recently a large series of *Phlebotomus* from the bartonellosis region of Colombia was received from Dr. Juan A. Montoya. Most of these specimens were found to be *incarum* and *colombianus;* however, it soon became evident that it was not possible to separate the females according to the characters described by Ristorcelli and Van Ty, and furthermore, it appeared that no differentiating characters could be found between the females from Colombia and *verrucarum* of Peru as described by Shannon (1929) and Hertig (1938). As males were present in the collections received from Dr. Montoya, the purpose of this study was to compare the Colombian insects with *verrucarum* from Peru in order to establish the relationship between *colombianus*, *incarum*, and *verrucarum*.

COMPARISON OF THE FEMALES

An analysis of the descriptions by Ristorcelli and Van Ty will show that the principal difference between *colombianus* and *incarum* is in the structure of the spermathecae, which are smooth-walled, pyriform organs in *colombianus*, while in *incarum* they show varying degrees of collapse. The females from Colombia were grouped according to the spermathecal characters described by Ristorcelli and Van Ty. Those with the collapsed spermathecae of *incarum* were designated as type I (figs. 1–3); those with the expanded spermathecae of *colombianus* as type II (fig. 6); and in addition a type III was recognized in which the

[1]From the Department of Parasitology, The Johns Hopkins School of Hygiene and Public Health. This work was supported in part by the International Health Division of the Rockefeller Foundation. The writer is indebted to Dr. Alan Stone for the opportunity to examine the material in the U. S. National Museum.

spermathecae were partially contracted but instead of narrowing down to the head, as illustrated for *incarum*, they were broad apically, so that they were somewhat beet-shaped (fig. 4). The principal reason for recognizing this type was that these specimens could be assigned with certainty neither to *colombianus* nor *incarum*. Of the 71 specimens studied, 40 were type I, 10 were type II, and 21 were type III. After grouping the specimens according to the spermathecae, other characters were studied in an attempt to find differences between the groups which might supplement those of the spermathecae; in addition, information concerning *verrucarum* was obtained from Shannon (1929) and Hertig (1938), by examination of Townsend's type and two cotype slides in the U. S. National Museum, and by staining and dissecting three female *verrucarum* that had been collected in Peru and identified by Hertig. Measurements and certain ratios are summarized in Table I; the former are given in microns and represent the mean measurements of Townsend's type and cotypes of *verrucarum*, the three Peruvian specimens of *verrucarum* and the three types of Colombian specimens. Measurements of *colombianus* and *incarum* are taken directly from Ristorcelli and Van Ty (1941). Because of the wide variations in the wing vein ratios the range rather than the mean of these values is listed. The shrinkage of the spermathecae and their ducts limited the significance of the mean values, and the range of the measurements of these structures is given.

The total length of the specimens is not given in the table, as the great variation observed in the size of the abdomen would seem to make its length of little significance for purposes of comparison. In general, the overall length of the Colombian specimens averaged about 2.5 mm., which is similar to that of the other forms under consideration.

The antennal formula in *colombianus* and *incarum*, according to Ristorcelli and Van Ty, is III>IV+V; III<IV+V+VI; this is also the formula of the types of *verrucarum* and of the Colombian specimens.

There is considerable variation in the length of the palpal segments. In Townsend's types, the fifth segment is relatively much shorter than in the other Peruvian *verrucarum*. Segment II may be shorter, equal to, or longer than III, so that the formula for *verrucarum* and for the Colombian specimens is 1, 4, 2, 3, 5; 1, 4, (2, 3), 5; or 1, 4, 3, 2, 5. The measurements of the palp of a single specimen of *incarum* given by Ristorcelli and Van Ty are remarkably short, totalling less than the usual length of the "short-palp" species, in which segment V is shorter than segment III. None of the "type I" specimens, with spermathecae like those described for *incarum*, has such a short palp.

The modified spines of Newstead are described as being present on the apical three-fifths of palpal segment III in *colombianus;* they were

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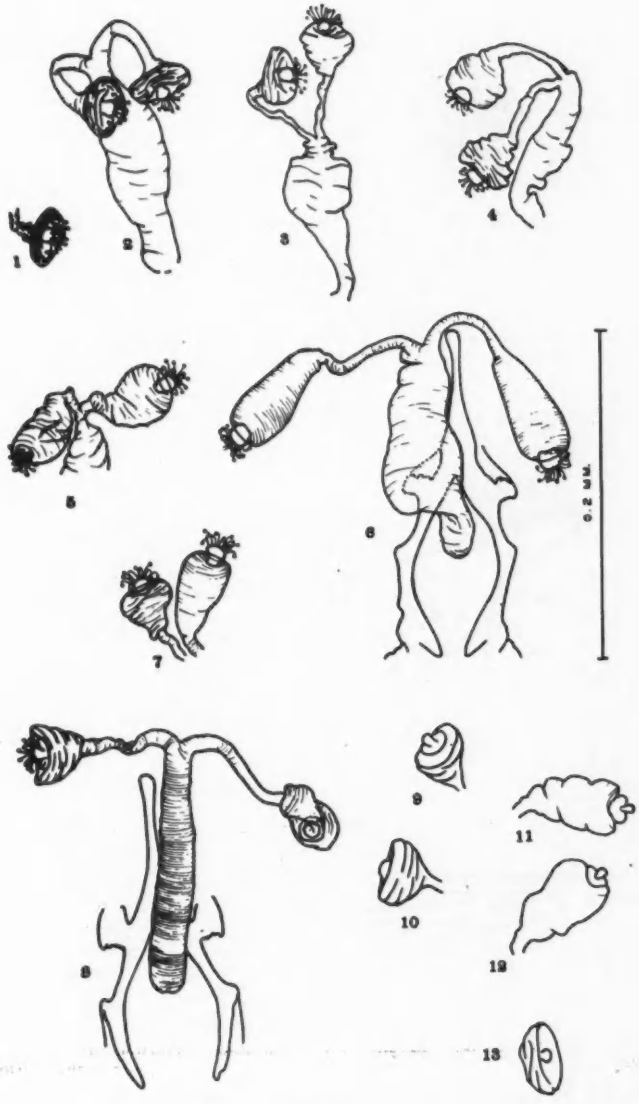
EXPLANATION OF PLATE I

FIGS. 1–3. *P. colombianus* ("Type I"—*incarum*). Spermathecae and ducts. FIG. 4. *P. colombianus* ("Type III"). Spermathecae and ducts. FIG. 5. *P. colombianus*. Spermathecae and ducts. FIG. 6. *P. colombianus* ("Type II"). Spermathecae and ducts. FIG. 7. *P. colombianus*. Spermathecae and ducts. FIG. 8. *P. verrucarum*. Spermathecae and ducts. FIGS. 9 and 10. *P. verrucarum*. Spermathecae of Townsend's cotypes. FIGS. 11–13. *P. verrucarum*. Spermathecae.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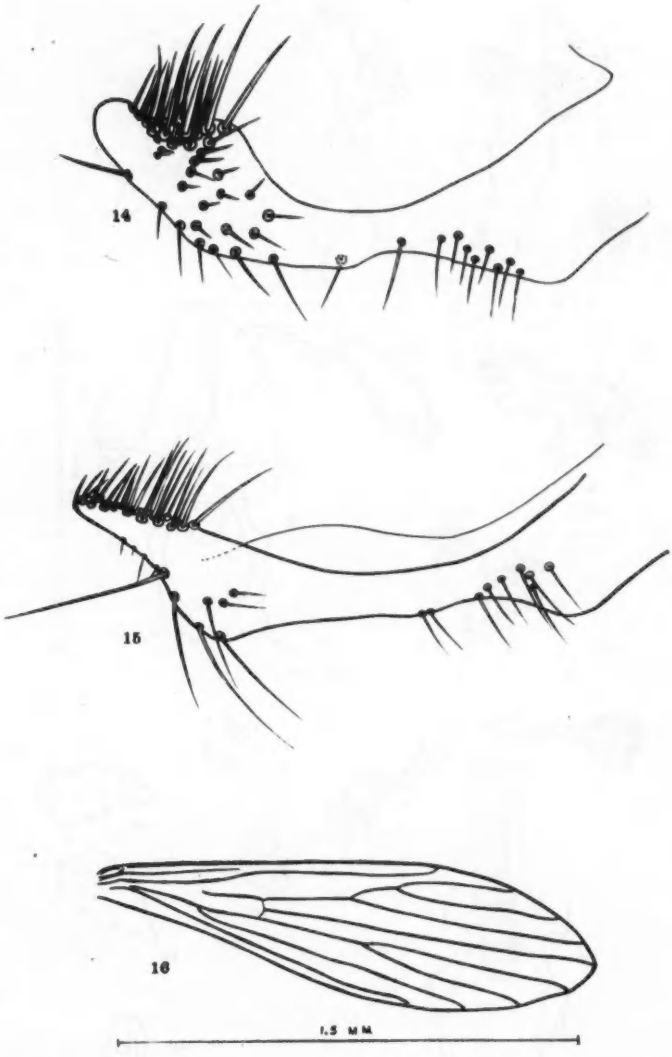

FIG. 14. *P. colombianus*. Median clasper of male genitalia. FIG. 15. *P. verrucarum*. Median clasper of male genitalia. FIG. 16. *P. colombianus*. Wing of male.

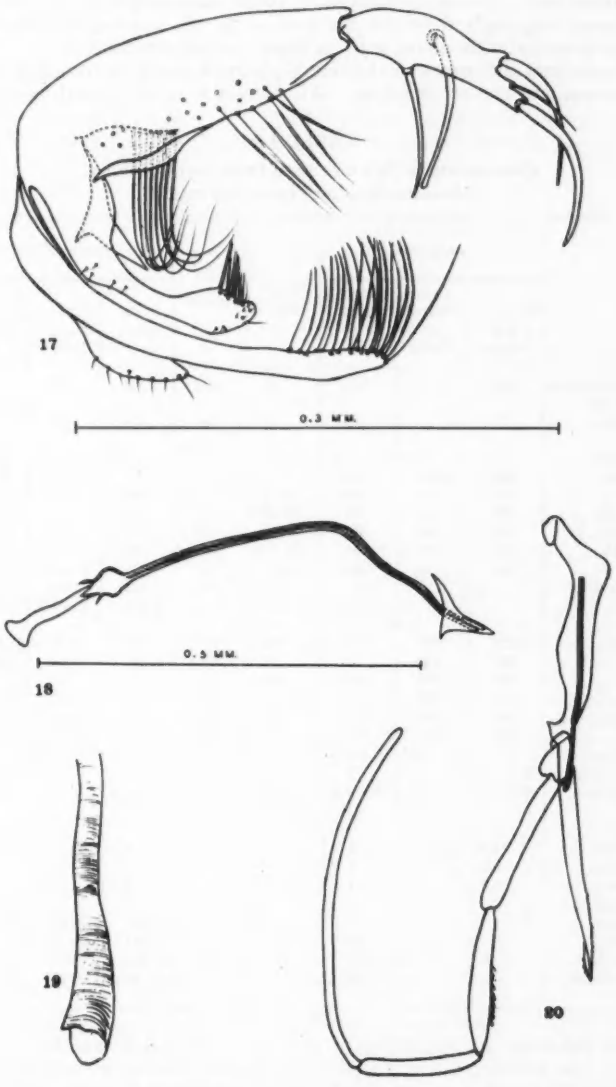

FIG. 17. *P. colombianus*. Male genitalia. FIG. 18. *P. colombianus*. Genital filaments and pump. FIG. 19. *P. colombianus*. Tip of genital filament. FIG. 20. *P. colombianus*. Palp, maxilla, and maxillary sclerotization of female.

approximately in the same position in ***verrucarum*** and in the Colombian specimens, although they did not extend to the apex of the segment and in some individuals occupied a more central position.

No distinct difference in the bucco-pharynx could be found between ***verrucarum*** and the other forms. All possess four horizontal teeth; the

TABLE I

COMPARISON OF FEMALES FROM PERU AND COLOMBIA

Measurements in microns and ratios

	verrucarum			colombianus	incarum	Specimens from Colombia		
	Holotype and Cotypes	From Shannon and Hertig	Specimens from Peru			"incarum" Type I	"colombianus" Type II	Type III
Head and clypeus.	447	.....	453	421	432	418	425	420
Scutum and scutellum.....	776	.....	585	648	658	528	556	536
Eye								
Eye-vertex.....	1.6	1.1	1.6	.....	.....	1.9	1.8	1.9
Antenna.....	1548	2000	1633	.....	.....	1605	1680	1638
Palp I.....	40	30	48	46–50	12	45	43	47
II.....	187	220	191	151–172	51	171	171	169
III.....	170	190	191	180–194	58	172	189	171
IV.....	110	130	135	118–136	35	129	134	128
V.....	248	360	389	396–432	154	423	430	441
Epipharynx.....	.....	.....	363	298–320	340	313	321	308
A III/E.....	.....	.....	0.8–0.9	0.9	0.9	0.9–1.3	0.9–1.5	0.9–1.1
Wing—								
Length.....	2423	2800	2531	2192	2036	2143	2112	2112
Width.....	745	800	752	702	750	665	677	657
Alpha.....	726	900	711	648	669	608	616	602
Beta.....	231	300	242	172	216	185	189	192
Gamma.....	483	520	459	378	432	382	382	374
Delta.....	308	340	284	248	280	223	235	208
Alpha/Beta.....	2.8–3.4	3.0	2.6–3.3	3.7–4.5	3.1	2.6–4.0	2.9–3.7	2.6–3.8
Alpha/Gamma..	1.3–1.6	1.7	1.3–1.7	1.7	1.5	1.2–1.9	1.4–1.8	1.5–1.8
Alpha/Delta....	2.3–2.4	2.7	2.4–2.9	2.6	2.4	2.5–3.6	2.3–3.1	2.3–3.3
Tibia								
Femur—								
Foreleg.....	1.1	.....	1.1	1.1	1.1	1.1	1.1	1.1
Midleg.....	1.3	.....	1.3	1.3	1.3	1.4	1.3	1.4
Hindleg.....	1.5	1.7	1.5	1.5	1.5	1.5	1.5	1.5
Spermatheca—								
Length.....	.....	.....	32	.....	.....	16–32	55–95	32–48
Width.....	.....	.....	24	.....	.....	32	32	32
Common duct....	.....	.....	112–145	.....	.....	80–104	120–136	96–128
Individual duct..	.....	.....	70	.....	.....	40	40–65	40–65

vertical denticles are usually arranged in an irregular double row, at least in the middle, although in some specimens the arrangement is such that it could be considered to be an irregular single row; the pigmented area usually is distinct although in some specimens it is indistinct; the upper portion of the pharynx is striated with short, denticulated lines. Hertig (1938) describes the sclerotized arch of

verrucarum as being complete and distinct; this also is true of the three *verrucarum* females from Peru. In the Colombian specimens the middle portion of the arch is less heavily pigmented, so that it is less distinct in this region, although the outline of the complete arch usually can be made out.

The posterior, ribbon-like band of the maxillary sclerotization (fig. 20) is broad in the Colombian specimens and is similar to Hertig's

TABLE II

COMPARISON OF MALES FROM PERU AND COLOMBIA

Measurements in microns and ratios

	Verrucarum		
	From Shannon	Specimens from Peru	Specimens from Colombia
Head and clypeus		396	356
Thorax		498	430
Eye/Eye-vertex		1.8	1.9
Antenna	2340-2370	1841	1650
Palp I	25-30	41	37
II	210-190	155	134
III	180-180	156	145
IV	130-150	116	114
V	270-480	332	357
Epipharynx		252	205
A III/E		1.2-1.4	1.3-1.7
Wing—Length	2350-2700	2002	1703
Width	650-650	546	477
Alpha	630-600	511	402
Beta	200-280	209	157
Gamma	450-470	380	303
Delta	180-200	162	98
Alpha/Beta	3.1-2.1	1.9-2.7	2.2-2.8
Alpha/Gamma	1.4-1.3	1.2-1.4	1.1-1.5
Alpha/Delta	3.5-3.0	2.9-3.5	3.4-5.3
Tibia			
Femur—Foreleg		1.1	1.1
Midleg		1.4	1.4
Hindleg	1.5-1.6	1.6	1.5
Genitalia—Coxite		237	208
Style		137	117
Median Clasper		200	168
Lower Clasper		327	254
Pump		162	172
Filaments		504	479

description of this structure in *verrucarum*. There is a band of sclerotization extending along the rod for some distance; this was also seen in the Peruvian *verrucarum*.

There is no real difference in the wing vein ratios. The relative lengths of the tibiae and femora are the same.

An examination of a series of spermathecae will show that the differences in their appearance are due entirely to the degree of collapse.

Shannon described the spermatheca of ***verrucarum*** as being "rosebud-shaped when contracted, bladder-shaped when expanded." Spermathecae of Shannon's specimens are illustrated in figures 11–13; the expanded spermatheca is similar to that of ***colombianus;*** the collapsed spermatheca is not unlike that of ***incarum***. The holotype and two cotypes of ***verrucarum*** are not cleared, and mounted in balsam. The outlines of the spermathecae of the cotypes can be made out with some difficulty; they are illustrated in figures 9 and 10, and it will be noted that they also show a moderate degree of collapse. The spermathecae and ducts of the Peruvian ***verrucarum*** are illustrated in figure 8; the former are collapsed, in one case longitudinally, the individual duct is short, and the median duct appears to differ from that of the Colombian forms in being of almost uniform diameter throughout its length. It is not certain that this character could be a point of difference between ***verrucarum*** and the Colombian forms, as a rather narrow common duct was observed in an occasional specimen from Colombia. This condition may be due to techniques of staining and mounting, as for example, incomplete clearing with KOH before staining with acid fuchsin. The spermathecae and ducts of the Colombian specimens are illustrated in figures 1 to 7. In all, the individual duct and common duct are short, and similar to these structures in ***verrucarum***, although the common duct usually is swollen. There is no sharp distinction between the collapsed, partially expanded, and fully expanded spermathecae. Figure 5 illustrates spermathecae which are slightly shrunken; figure 7 illustrates one partially collapsed and one fully expanded spermatheca from a single specimen. Furthermore, in the process of dissecting the spermathecae from the abdomen and mounting them in balsam, they have been observed to change from pyriform bodies into completely collapsed disks.

In summary, from the characters described above and those given in Table I, there seems to be no clear-cut way to separate the female of ***verrucarum*** from the Colombian specimens studied by the author and those described by Ristorcelli and Van Ty as ***colombianus*** and ***incarum***.

COMPARISON OF THE MALES

Associated with the females in the collections from Colombia so far studied, were 42 males. These males were compared with 3 male ***verrucarum*** collected in Peru by Hertig, and with Shannon's description. Shannon's mounted specimens in the U. S. National Museum were also examined. Table II summarizes the mean measurements in microns of the three Peruvian ***verrucarum*** and of 23 Colombian specimens; Shannon's measurements of ***verrucarum*** are given in microns; and certain ratios are listed, which in the case of the wing veins and A III/E represent the range instead of the mean. The total length of the Colombian males averaged about 2.2 mm., and that of the three Peruvian males was about the same. Shannon's specimens ranged from 2.2 to 2.8 mm. There is nothing in Table II which would permit the separation of the males from the two regions. The antennal formula is the same for each group: III>IV+V; III<IV+V+VI Shannon gives the palpal formula for ***verrucarum*** as being 1, 4, 3, 2, 5; in the three specimens from Peru it was 1, 4, 2, 3, 5, or 1, 4, (2, 3), 5.

In the Colombian specimens it was 1, 4, 2, 3, 5; 1, 4, (2, 3), 5, or 1, 4, 3, 2, 5.

In the male genitalia was found the only consistent difference between *verrucarum* from Peru and the Colombian males. In the former the median clasper (fig. 15) is swollen on the lower margin beyond the middle and tapers rather gradually to the apex, and there is a patch of upright setae on the upper surface at the extreme tip. In the male from Colombia (fig. 14) the median clasper also is swollen beyond the middle, but the upper margin is more concave, giving the shaft a more curved appearance; the apical portion is more swollen and does not taper gradually; the apex is broadly rounded, and the patch of setae on the upper surface is subapical in position. Furthermore, in *verrucarum* there is a dense clump of long setae on the ventral surface of the coxite below the apex; in *colombianus* these setae may be absent or are represented by only a few hairs.

THE MALE OF P. COLOMBIANUS

Because of the small but consistent differences in the males, *colombianus* would appear to be a different taxonomic entity than *verrucarum*, and as the male of the former has not been known, further descriptive notes are presented.

Total length about 2.2 mm. Wing illustrated in figure 16.

Geniculate spines of antenna without basal spur; situated one-third the distance from the apex on segment III, short, not reaching the apex of the segment; on the other segments they are situated near the base and are very short, not reaching the middle of the segments.

Genitalia (figs. 14, 17, 18, and 19).—Basal segment of upper clasper (coxite) with a basal lobe; a basal tuft near the lobe consisting of several long hairs arranged in a row; an irregular row of long, scale-like setae on inner margin before the apex. Distal segment of upper clasper (style) with four spines and a hair; arranged as follows: an apical and a subapical spine, between which is inserted the hair, and two spines inserted just before the middle. Lower clasper longer than the coxite; a group of long, scale-like setae at apex. Median clasper with upper surface strongly concave; the lower margin angled before the middle; the middle portion narrowed; the distal portion swollen and narrowing abruptly into a broadly rounded tip; a subapical patch of short, stout, upwardly-pointing setae before the tip on the upper surface; a number of small scattered setae on the inner surface of the swollen apical portion; and a short but prominent subapical seta on the lower margin; short setae along the lower margin of the shaft, somewhat denser beyond the angle. Genital spicules about three times the length of the pump, striated and somewhat enlarged apically, the tips blunt.

DISCUSSION

In spite of the exceedingly short palp described for *incarum*, a number of females from Colombia were identified as this form because they agreed in all other respects with the description given by Ristorcelli and Van Ty, particularly in the structure of the spermathecae. Because all degrees of variation were seen between the completely collapsed and fully expanded spermathecae, and as no other differences could be

found, it is concluded that *P. monticolus* var. *incarum* is a synonym of *P. colombianus*. Additional evidence that the three types of Colombian females studied are all one species results from the fact that all of the 42 males associated with these females represent a single species.

P. colombianus is very closely related to *verrucarum*. There seem to be no definite characters by which the females can be separated from one another. The only certain means of distinction between the males appears to be in the shape of the apical portion of the median clasper. In *verrucarum* the basal and subapical hair tufts on the coxite are more dense, and the lower clasper is longer.

Whether *colombianus* is sufficiently distinct from *verrucarum* to merit specific rank, or should be considered to be a geographically separated subspecies, can not be determined by morphological comparisons. *P. colombianus* must be very similar to *verrucarum* in its habits, especially in its willingness to utilize man as a source of blood. In the collections so far identified from the bartonellosis area of Colombia it was the predominant species. As many of the specimens were captured in houses in an engorged state, this species is to be suspected as being responsible for the transmission of Oroya fever in Colombia.

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